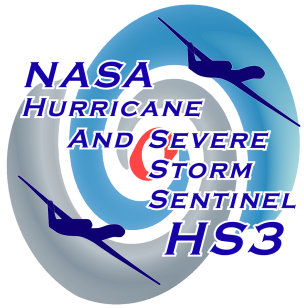


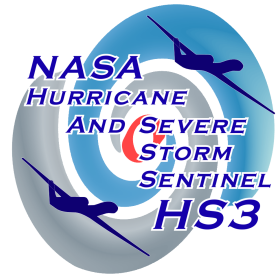
Hurricane and Severe Storm Sentinel (HS3) Integration and Test Fights

HS3 Pacific Flight

September 8-9, 2011

Dryden Flight Research Center

Instruments and Key Measurements

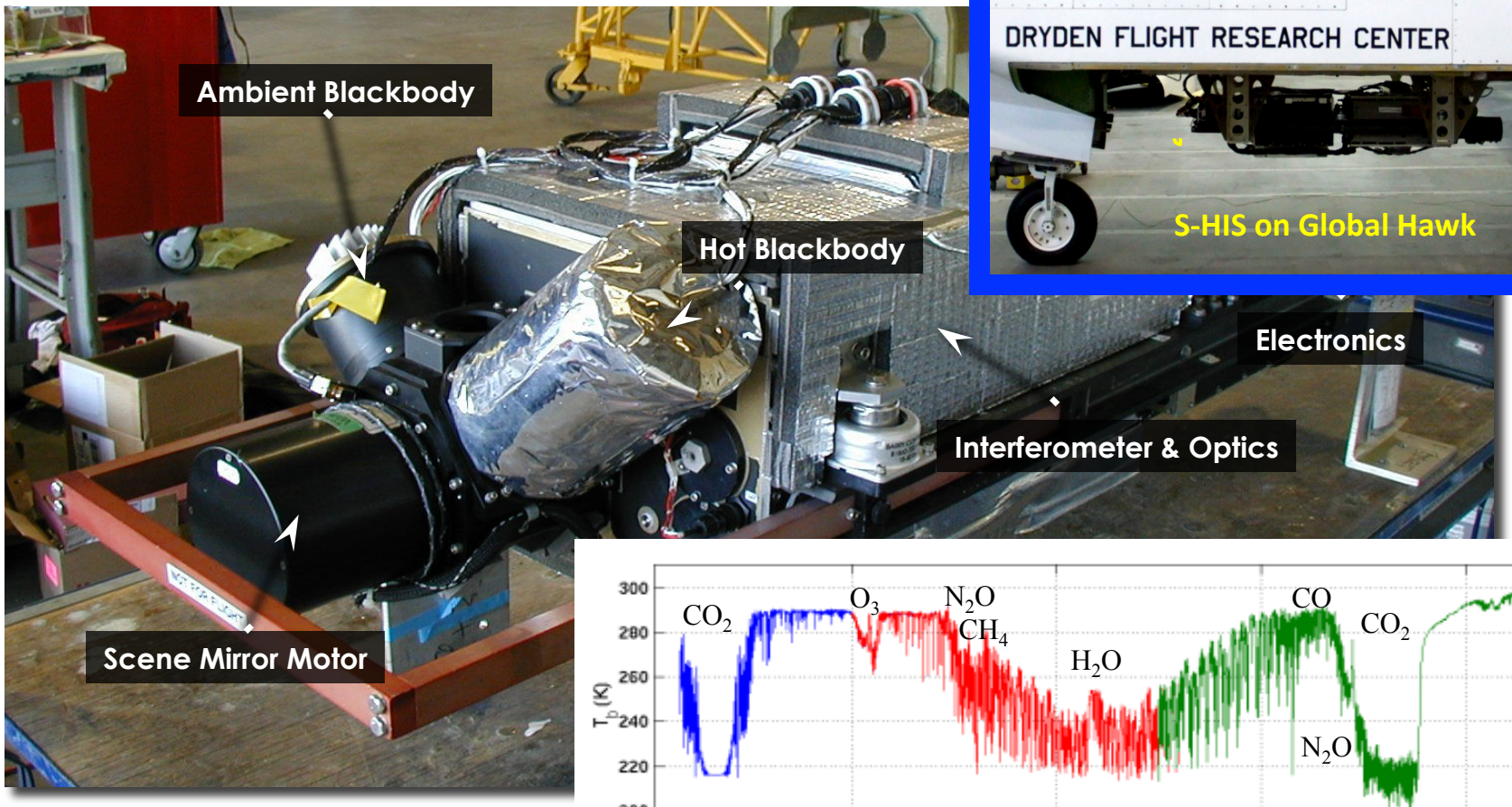


- Cloud Physics Lidar (CPL)
  - Cloud and aerosol backscatter
- Scanning High-resolution Interferometer Sounder (S-HIS)
  - Temperature and humidity profiles in clear air, 1-2 km vertical resolution
- High-Altitude MMIC Sounding Radiometer (HAMSR)
  - Temperature and humidity profiles in clear and cloudy air, 1-2 km vertical resolution
- Advanced Vertical Atmospheric Profiling System (AVAPS)
  - Very high vertical resolution temperature, humidity, and wind profiles from in-situ sensors on dropsonde

Integration Activities

- CPL, HAMSR, and AVAPS were all “returning” instruments
- S-HIS was the only new instrument to be integrated

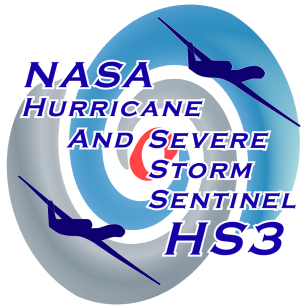
UW Scanning HIS



Test Flights

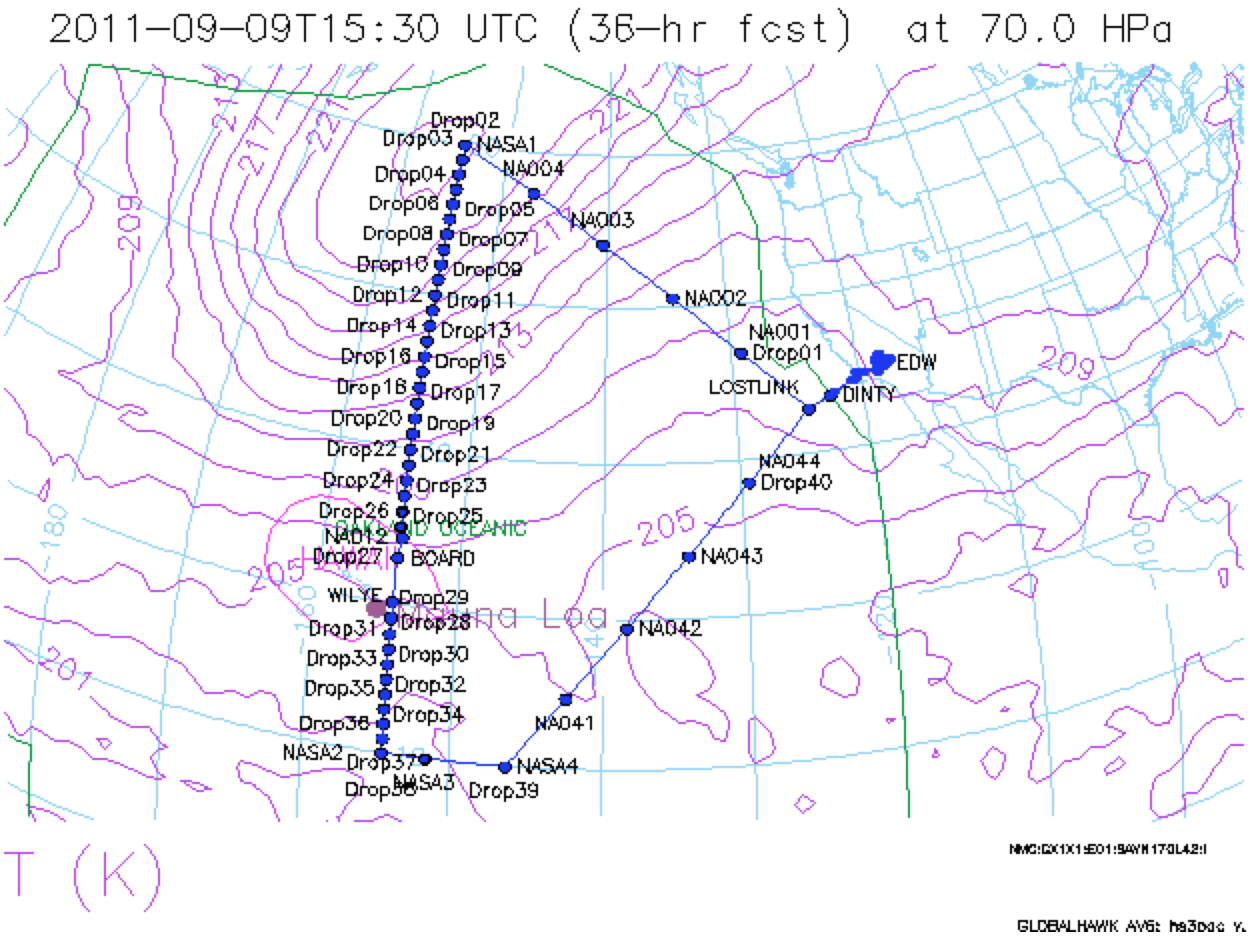
- HS3 conducted three test flights in 2011
  - Range flight to test dropsonde release (required because original tests included use of the deep radome, no longer to be used for HS3 on AV-6) and test CPL and S-HIS. Range flight on Sept 1, was 5 hours, 50 minutes.
  - Pulled CPL off after range flight, put on HAMSR
  - Pacific Flight for instrument intercomparison
  - Gulf of Mexico Flight for coordinated flight with NOAA G-IV to intercompare dropsondes

Pacific Flight Objectives



- Primary goal: Test S-HIS, HAMSR, and AVAPS instruments for data acquisition and instrument intercomparison
- Secondary goals:
  - Flight and Payload Operations Rooms communications
  - Ku and Iridium links
  - COMPASS system for real-time mission monitoring
  - ATC and Flight Operations communications for science operations

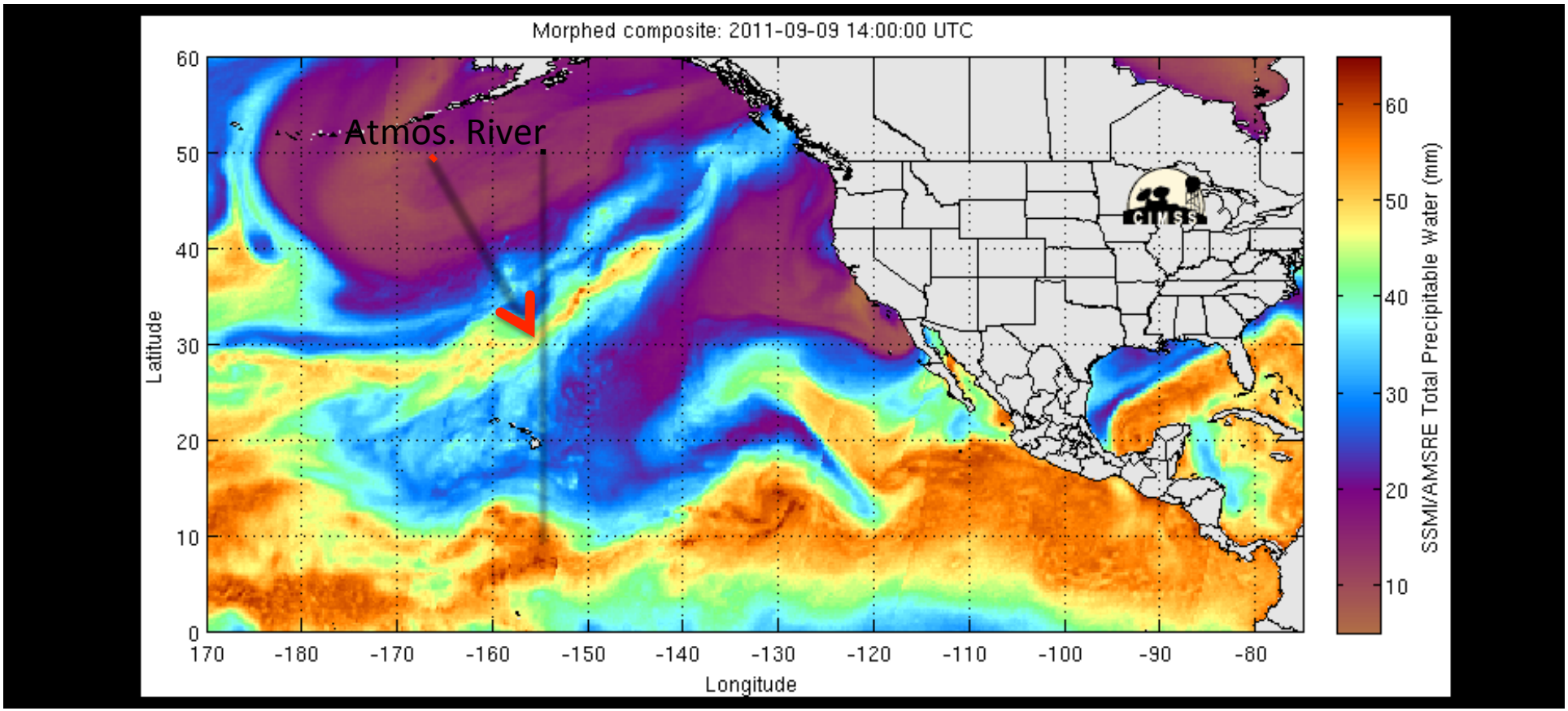
Flight Pattern



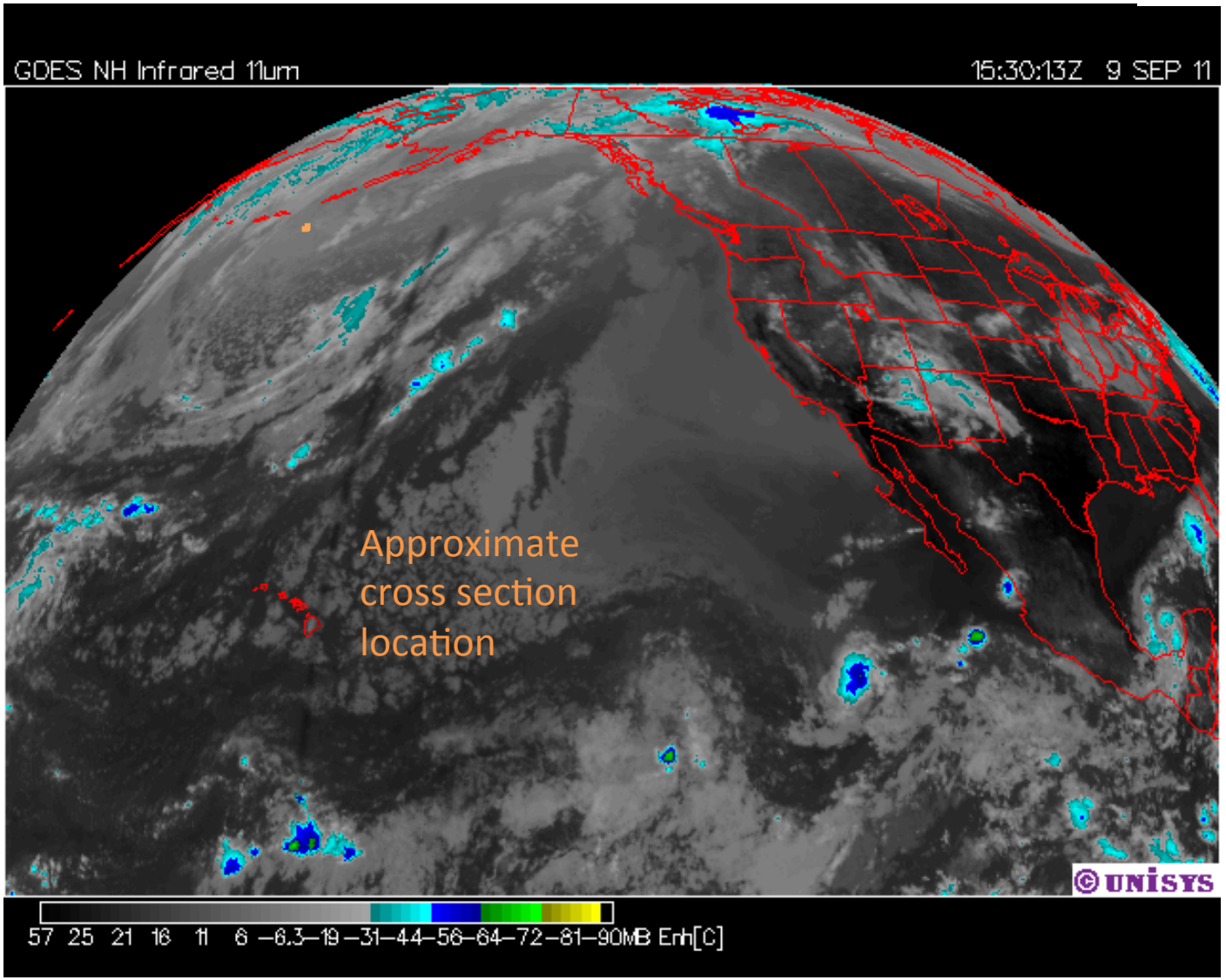
Pattern designed to provide wide range of temperature and humidity conditions

35 dropsonde release locations between 50°N and 10°N with 5 double drops to test new AVAPS temperature sensor.

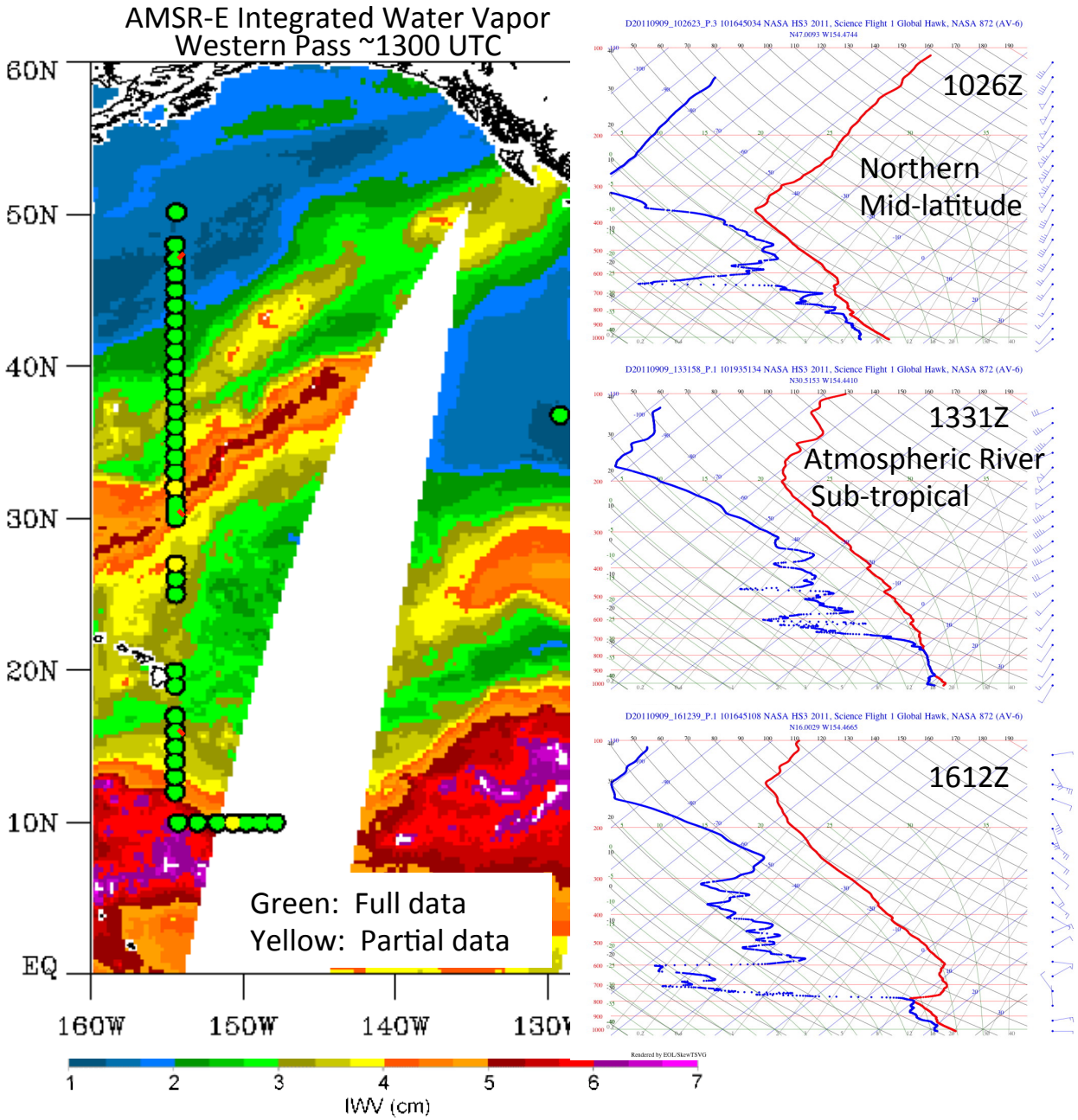
Total Precipitable Water: Pacific Atmospheric River



GOES Infrared Image



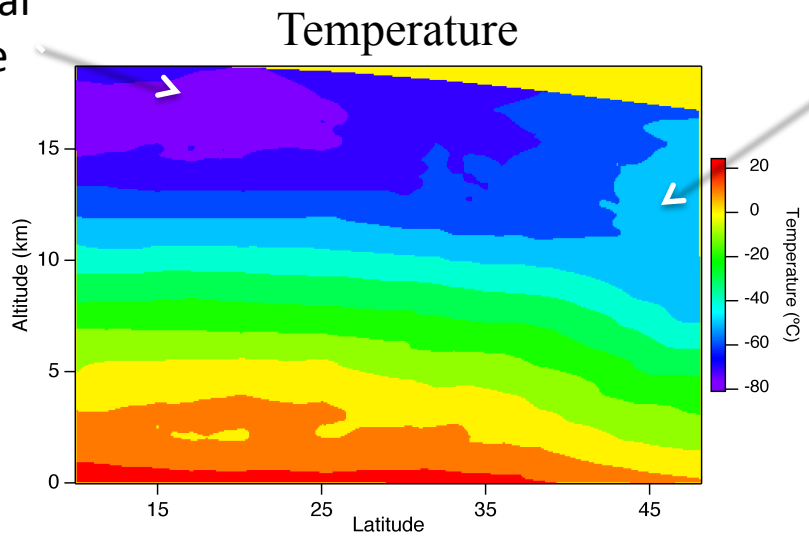
Preliminary Dropsonde Results



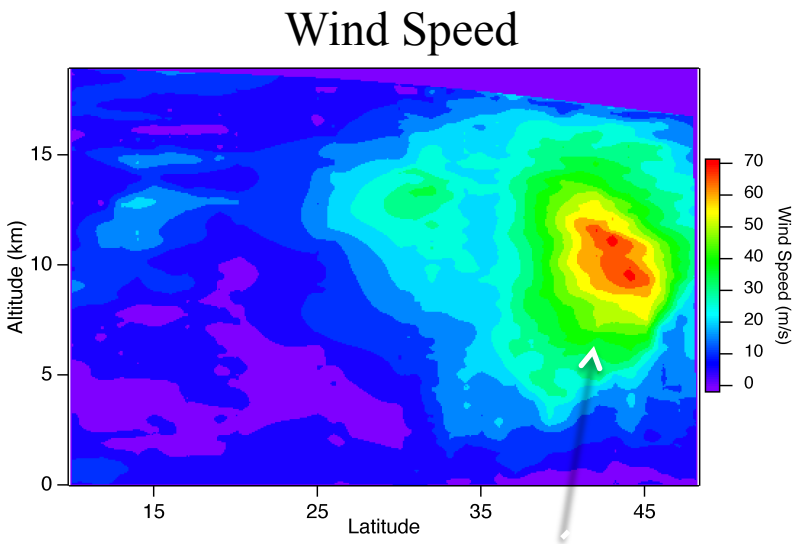
- Dropsondes sampled an extremely wide range of atmospheric conditions during N-S transect
- 45 sondes deployed
- Northern, mid-latitude soundings show strong polar jet stream
- Sounding within atmospheric river shows high moisture content but relatively weak transport at low levels
- Southern, tropical sounding shows moist boundary layer capped by inversion and drier air aloft

North Pacific Cross Sections
32 Dropsondes, 10°N – 48°N

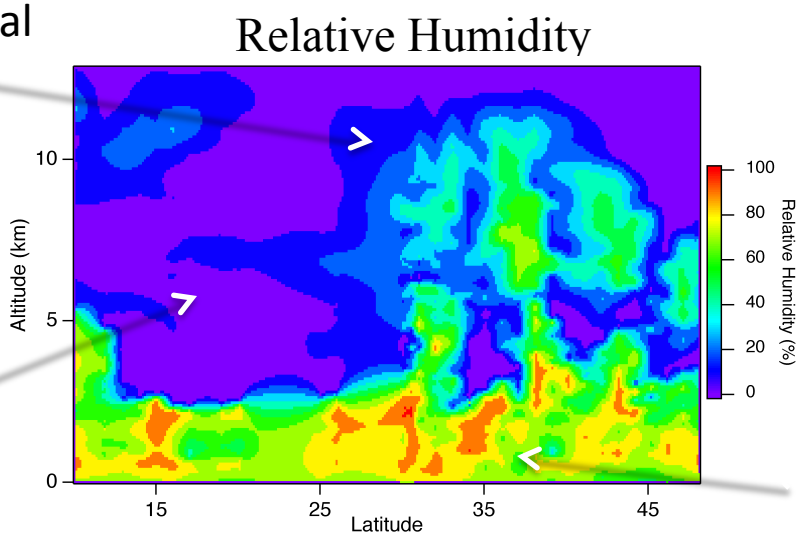
Cold tropical tropopause



Stratospheric air



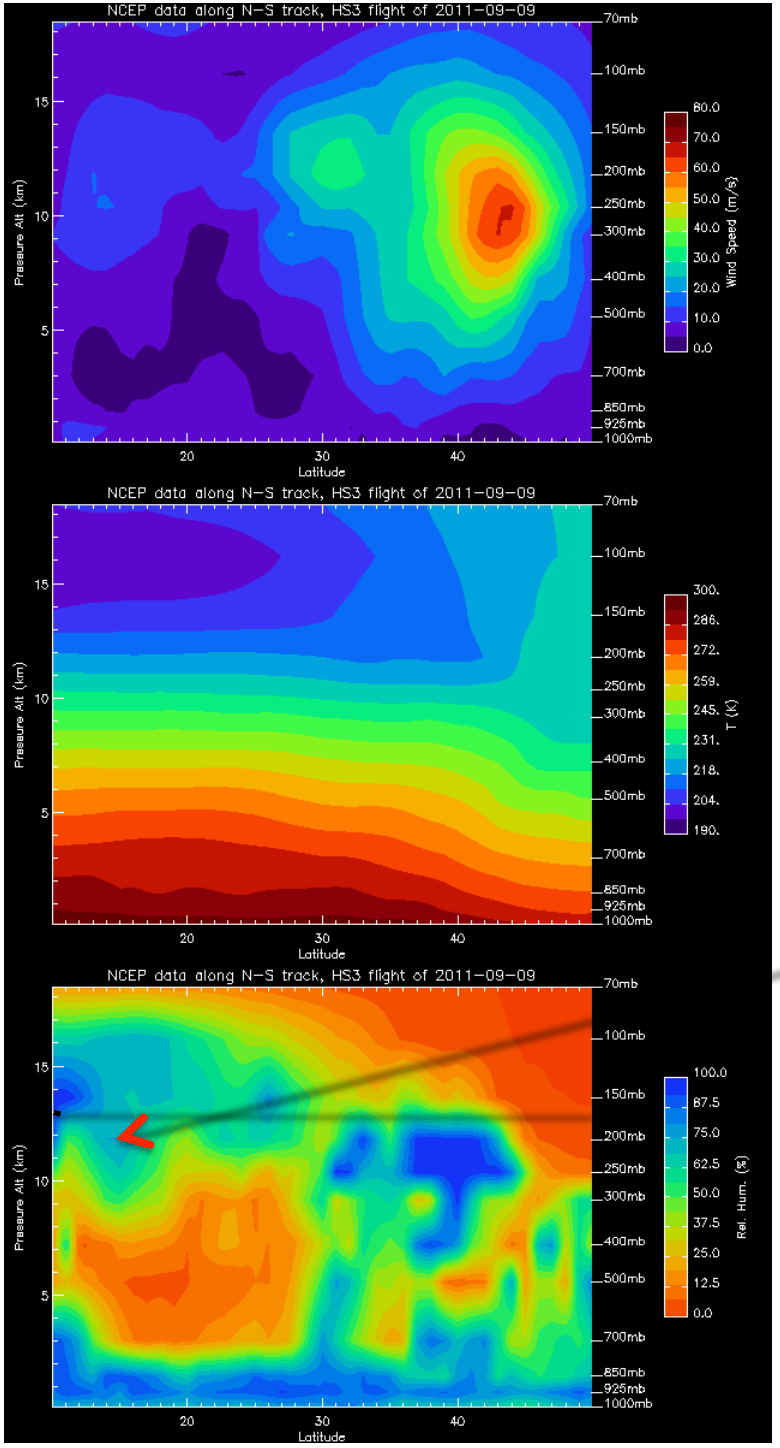
Extratropical storm



Strong polar jet stream in the upper troposphere at midlatitudes

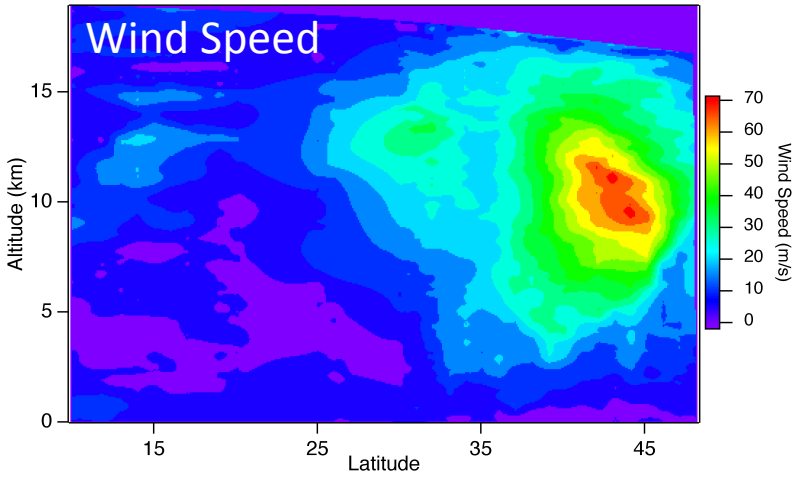
Dry subtropics

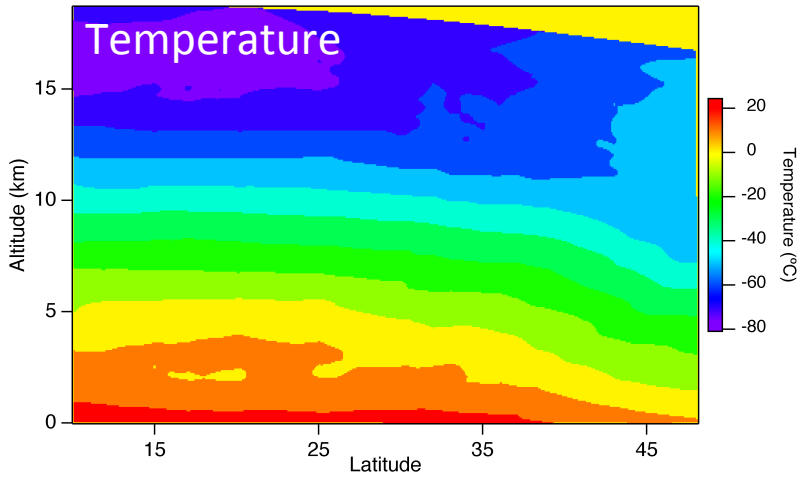
Atmospheric River

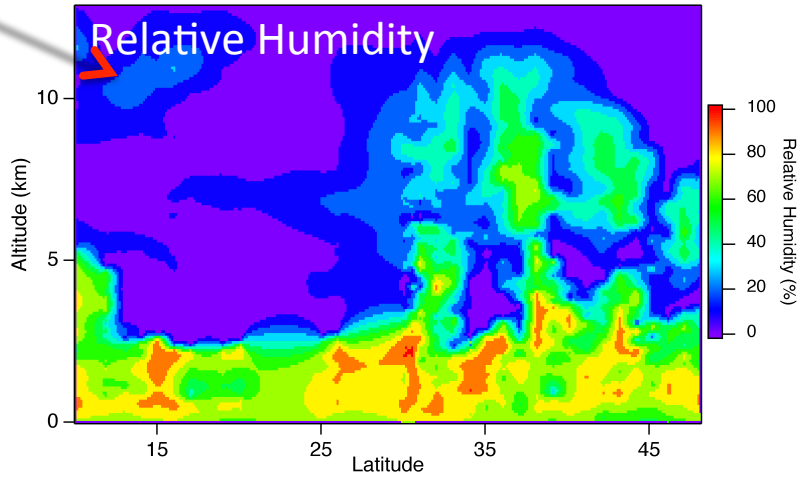


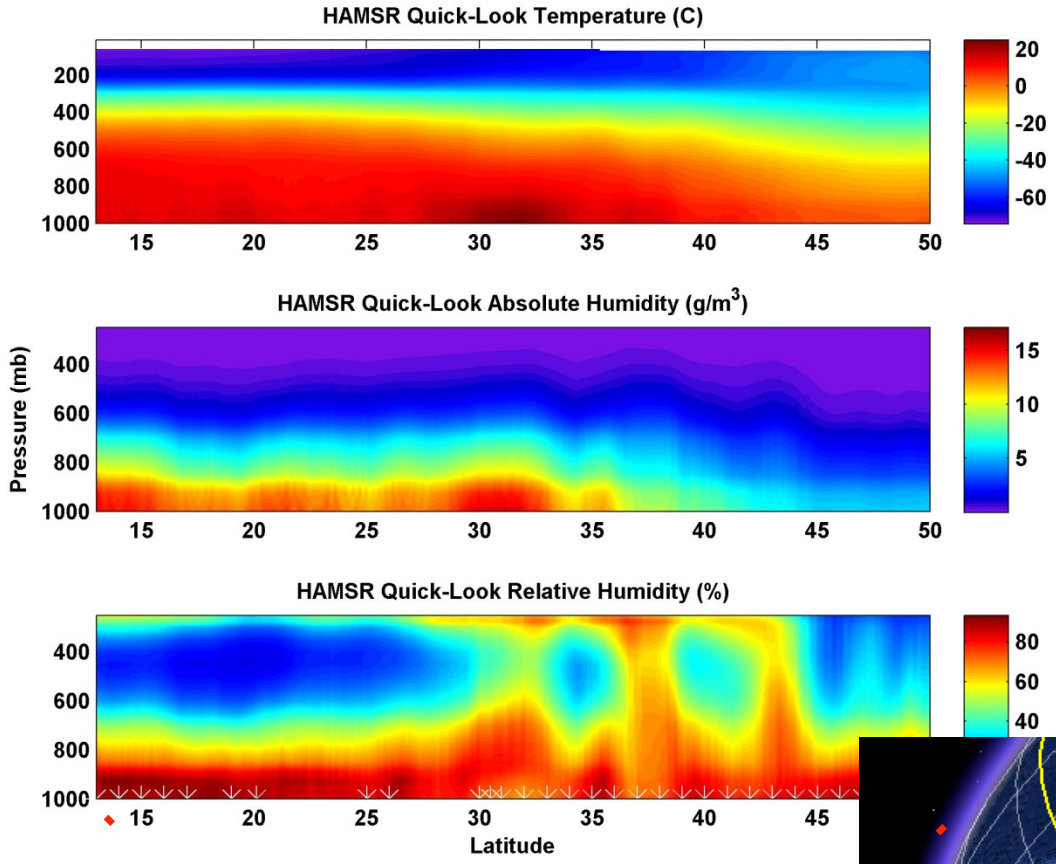
Sonde (right) comparison to NCEP analysis (left)

Drier tropical tropopause



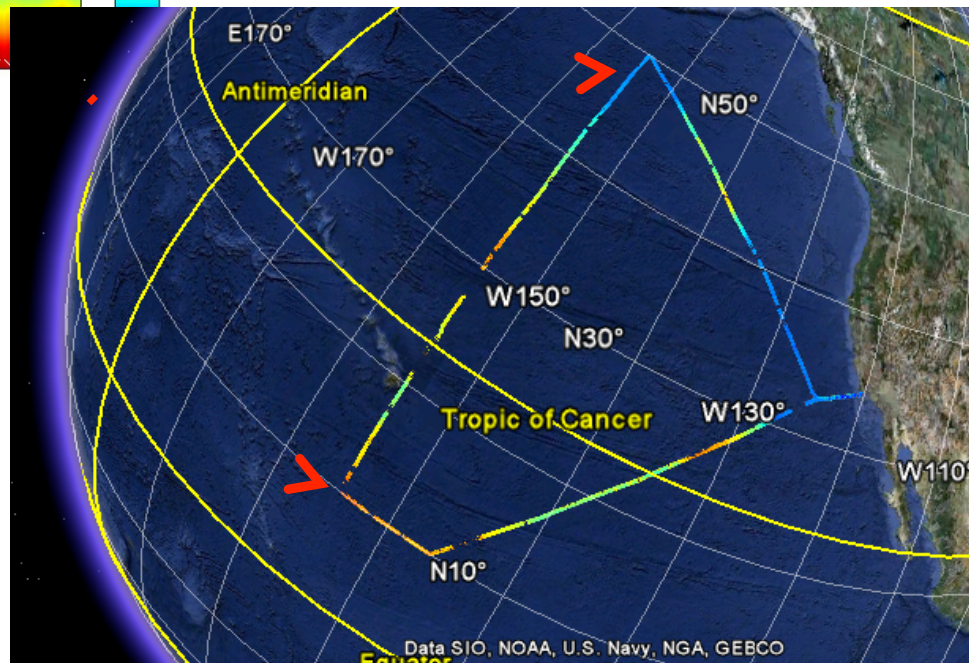






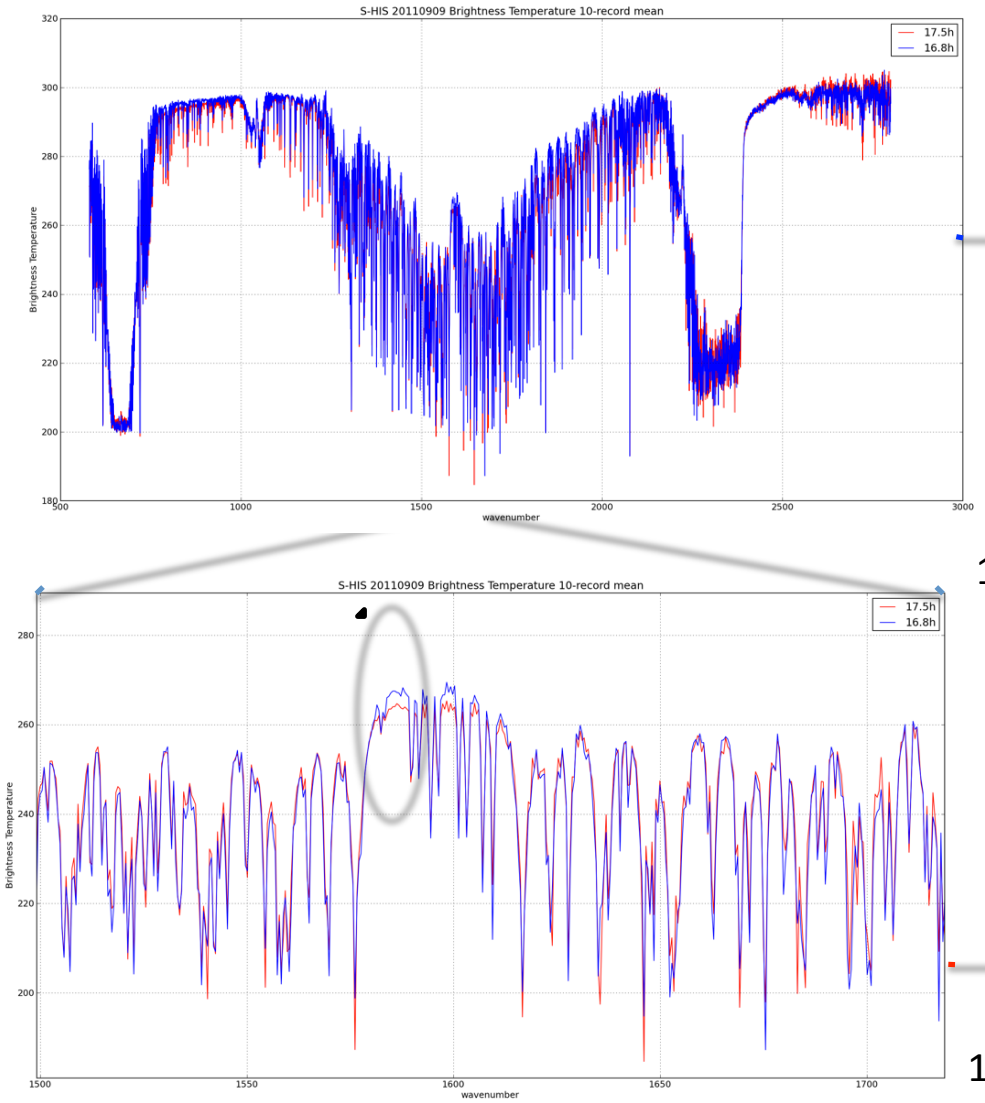
HAMSR Cross Sections

- HAMSR quick-look profiles shown for N-S leg of flight path of 9/8 flight



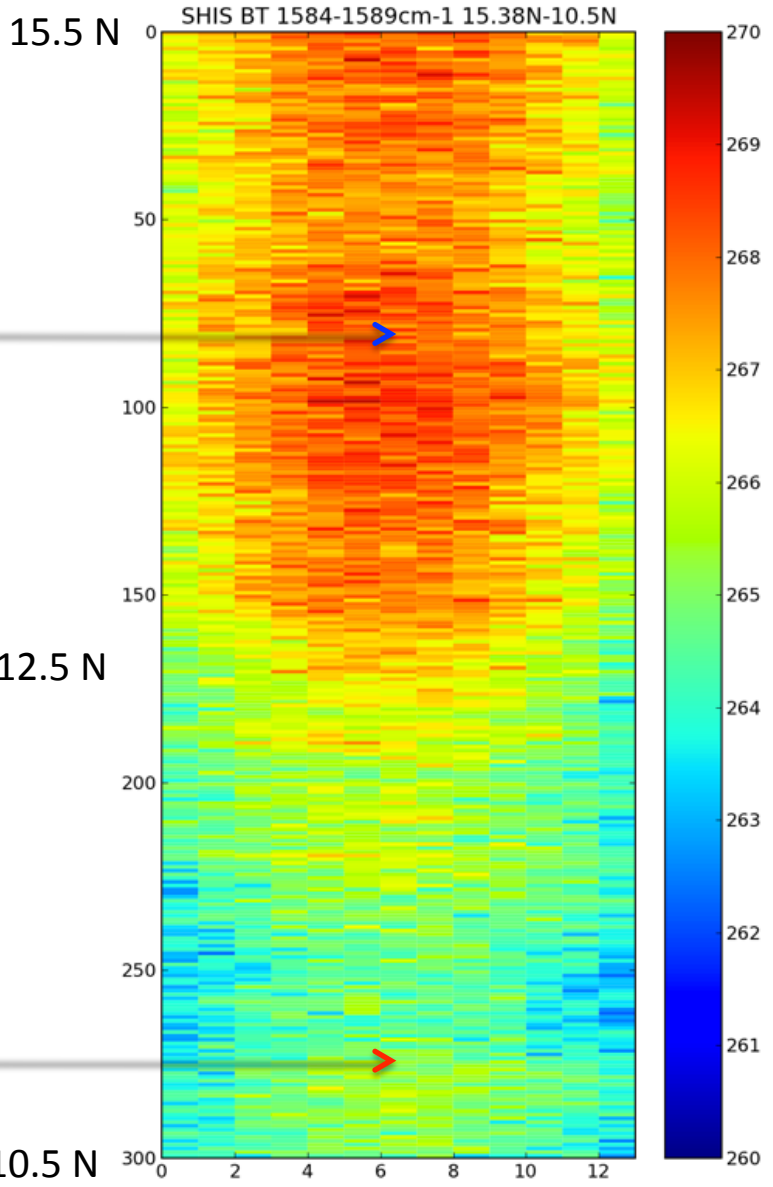
Scanning-HIS Brightness Temperatures

Observed Spectra (9/9/2011)



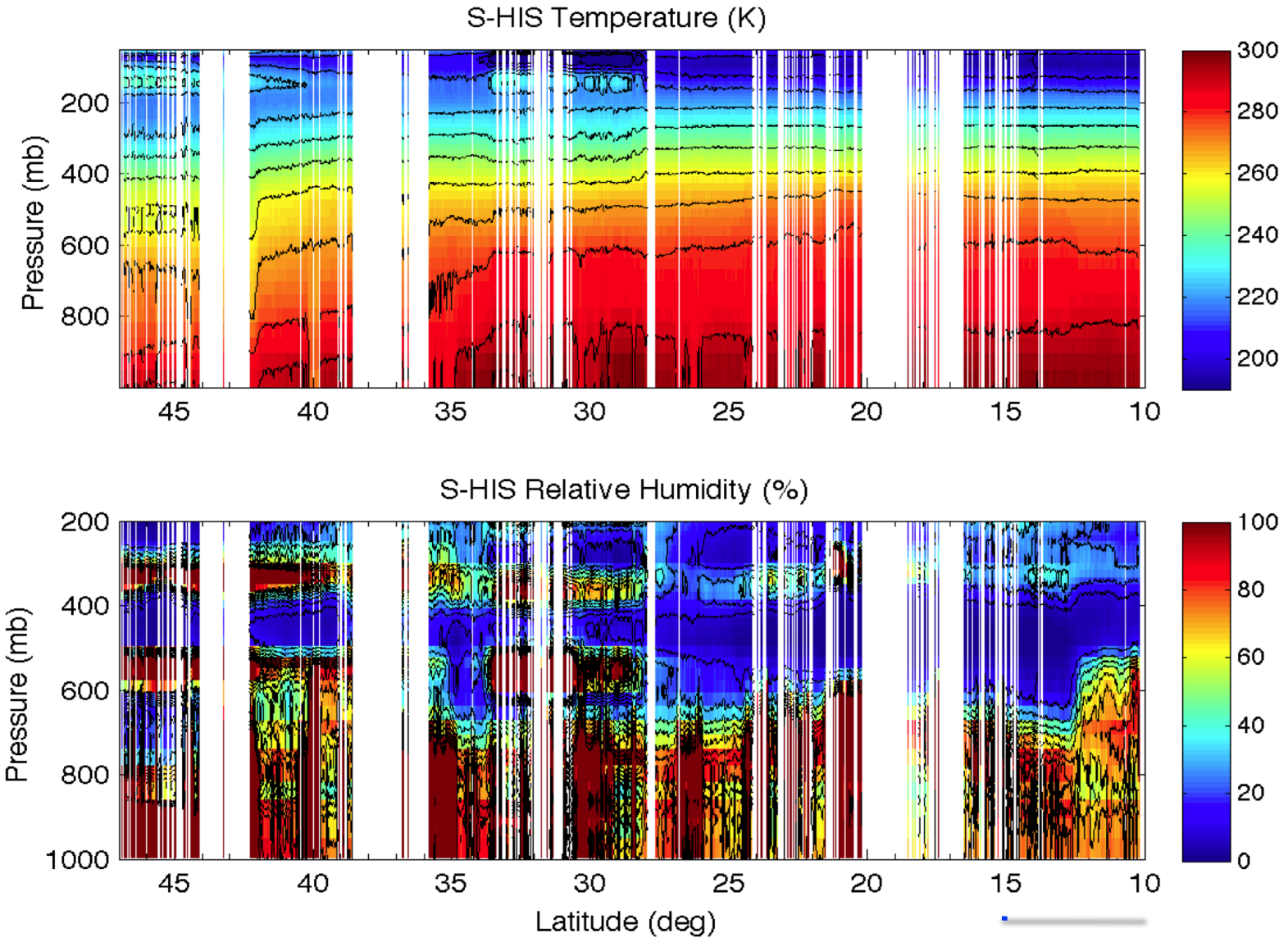
1500 Wavenumber (cm^{-1}) 1700

B.T. Map 1584-1589 cm^{-1}



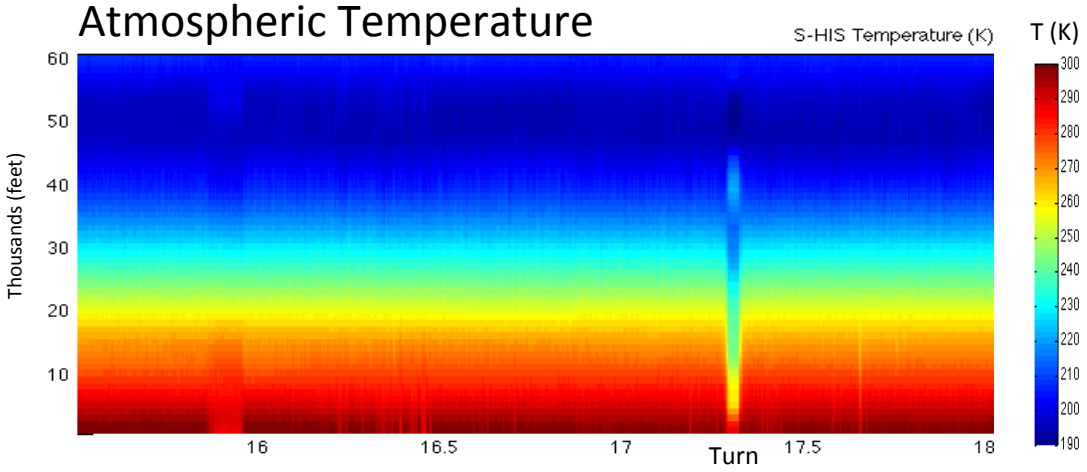
16.3-17.2 UTC 9/9/2011

UW Scanning-HIS T/WV Retrieval Example: 9/9/2011

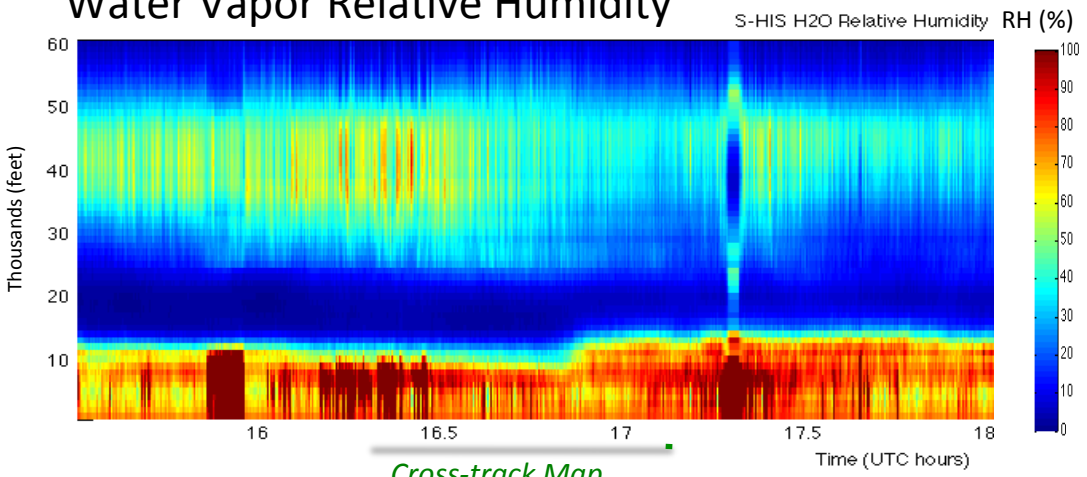


UW Scanning-HIS Quicklook Retrieval: 15.5-18.0 UTC 9/9/2011

Atmospheric Temperature



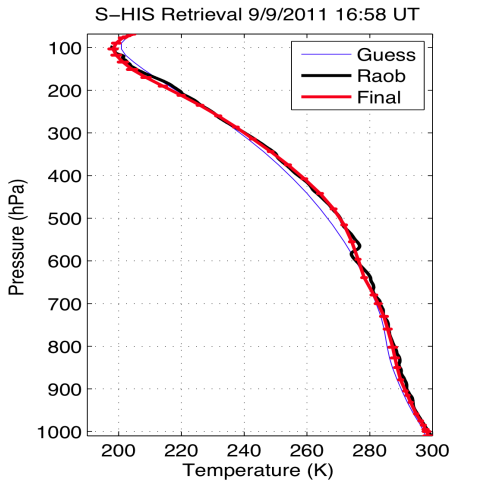
Water Vapor Relative Humidity

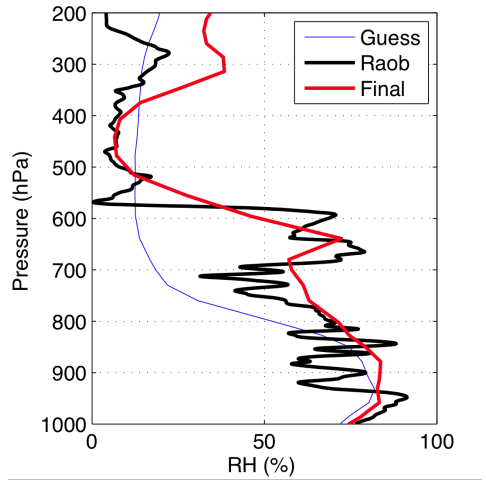


Cross-track Map

Mid-level Water Vapor Change

Dropsonde Time





NOAA Dropsonde
9/9/2011 16:58 UTC

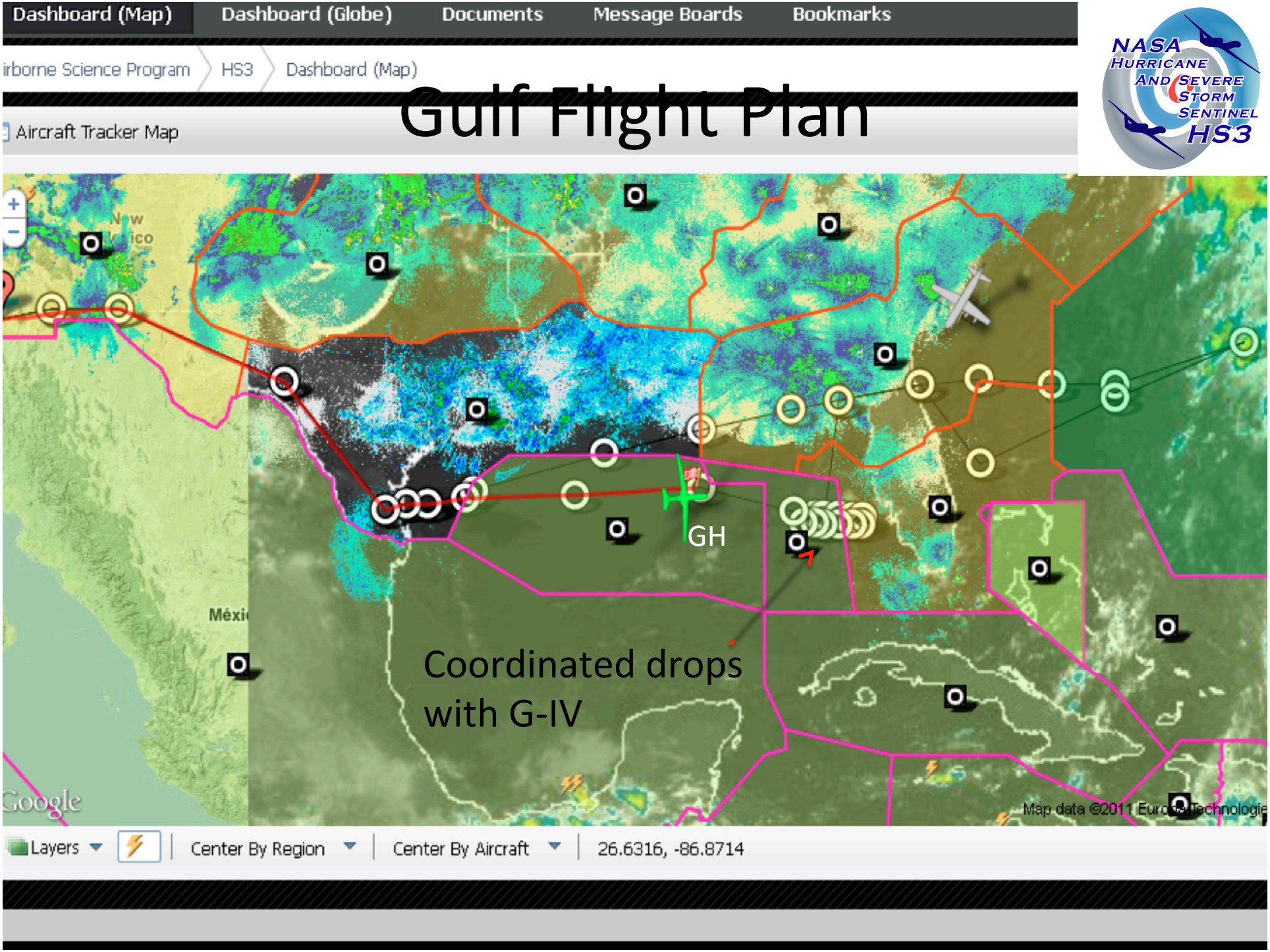
Key Accomplishments—Pacific Flight

- All instruments performed well, collected data over the entire flight
- Instruments now science qualified
- Ku did receive, but did not transmit properly; Iridium worked well with only brief outages
- Coordination between pilots and ATC worked very well
- Overflight of Hawaiian airspace went well with two sondes within FIR
- Flight was 23 hours, 4 minutes (Take off Sept 8 at 8:11pm local and landing Sept 9 at 7:15pm local)

Gulf Flight—September 13-14

- Goals
  - Intercomparison between GH dropsondes and NOAA G-IV dropsondes
    - Allows improved error characterization of GH sondes
    - Will facilitate use by data assimilation groups
  - GHOC and ATC communication in Houston, Miami, and New York Oceanic Flight Information Regions
  - Test zone 25 temperatures for S-HIS after removal of a seal to allow colder air into zone
    - May remove need for air inlets for flights in 2012

Gulf Flight Plan

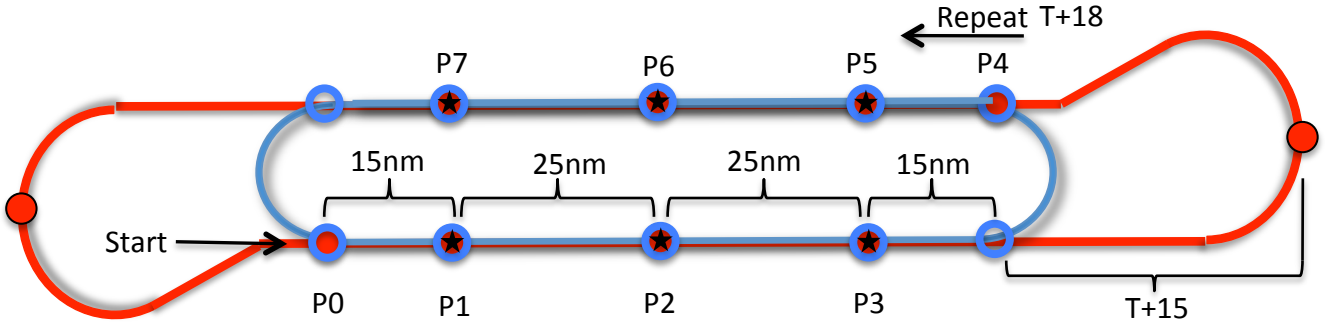


Racetrack Pattern For Sonde Intercomparison

Global Hawk
80nm =14:20@335kn
FL600
180ºTurn=3:30 rad=6.5nm
Bank angle=15º
½ Loop =18min

GIV-SP
105nm = 14:00@450kn
FL430
210ºTurn=4:00 rad=8nm
Bank angle=20º
½ Loop =18min

★ Dropsonde Launch Location



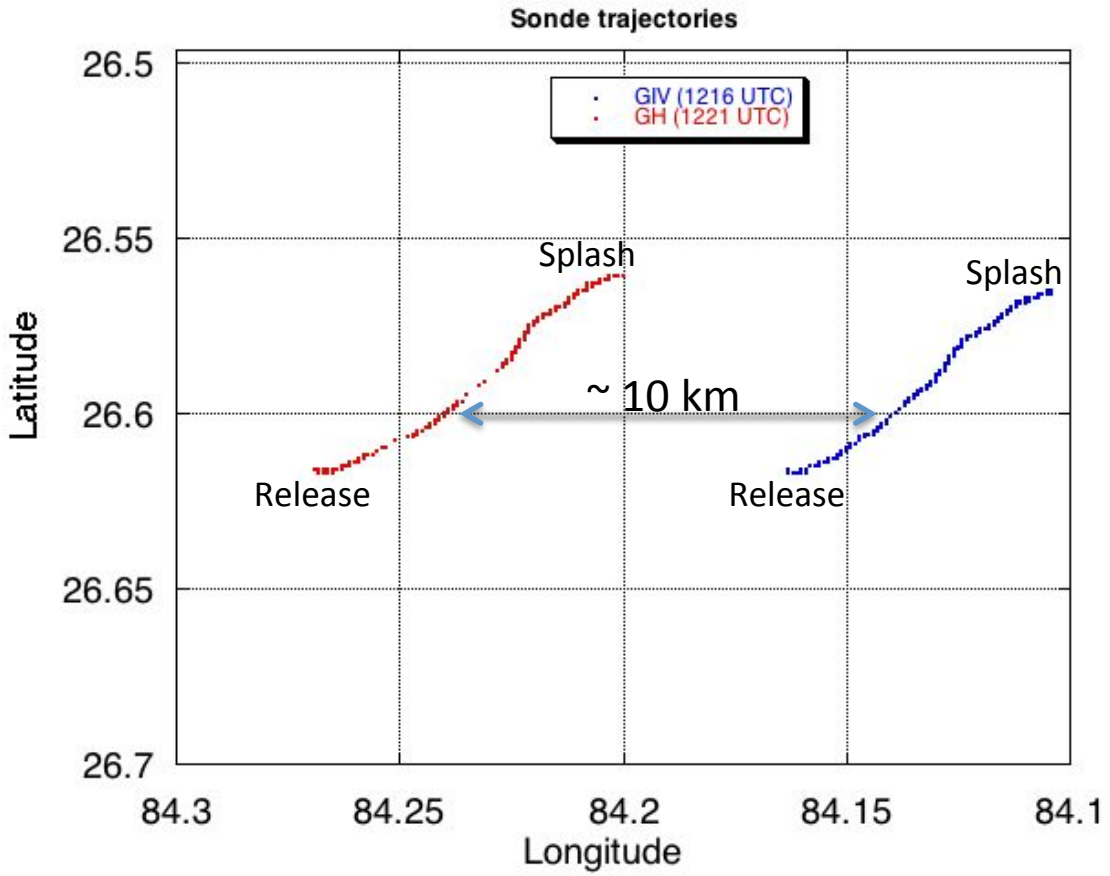
Both aircraft release 3 sondes each leg

Assumptions
- GH will experience minimum winds at FL580.
- Loop begins with both aircraft rendezvous at 'P0' WPT (repeat at T +18 WPT).
  Note: T+18 = PO mark time + 18 min.
- GIV should lead GH by 5.1nm before 1st GH sonde launch @ P1

Position	Distance (NM) Btwn Aircraft When GH Drops
P0	0.0
P1	5.1
P2	13.7
P3	22.3

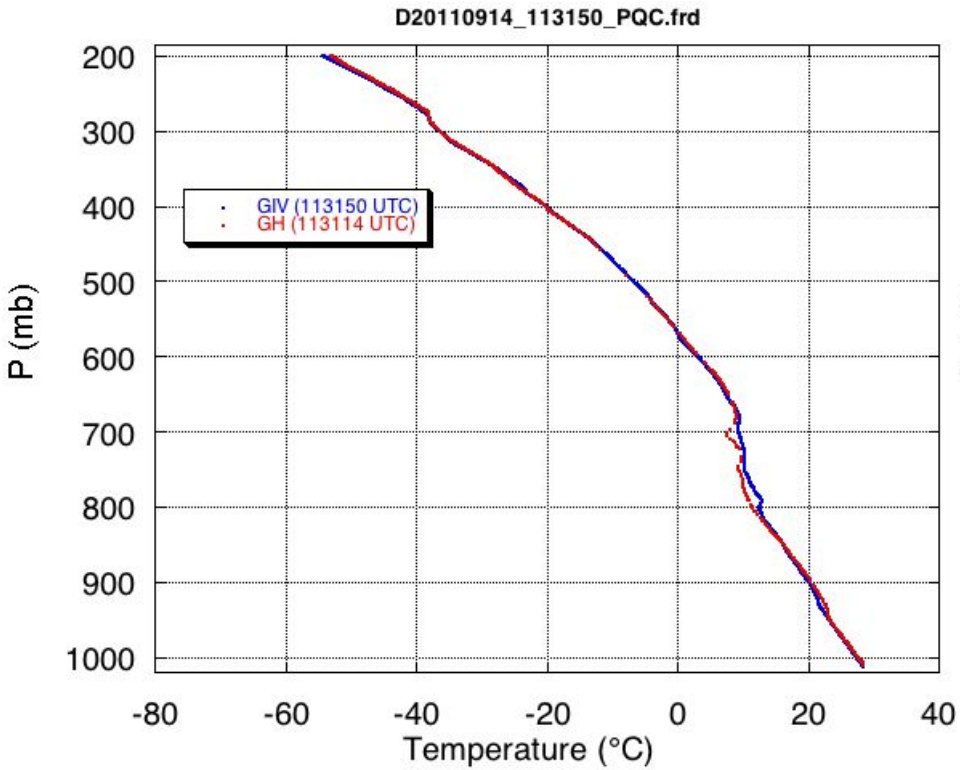
Mission Rules
1. GIV must verify that position is 2nm ahead of GH before GH will release sonde. (GIV will mark over point P1, P2, P3,…)
2. Direct pilot to pilot communications via SATCOM or VHF radio is required before sonde release.

NASA Global Hawk and NOAA G-IV dropsonde comparisons

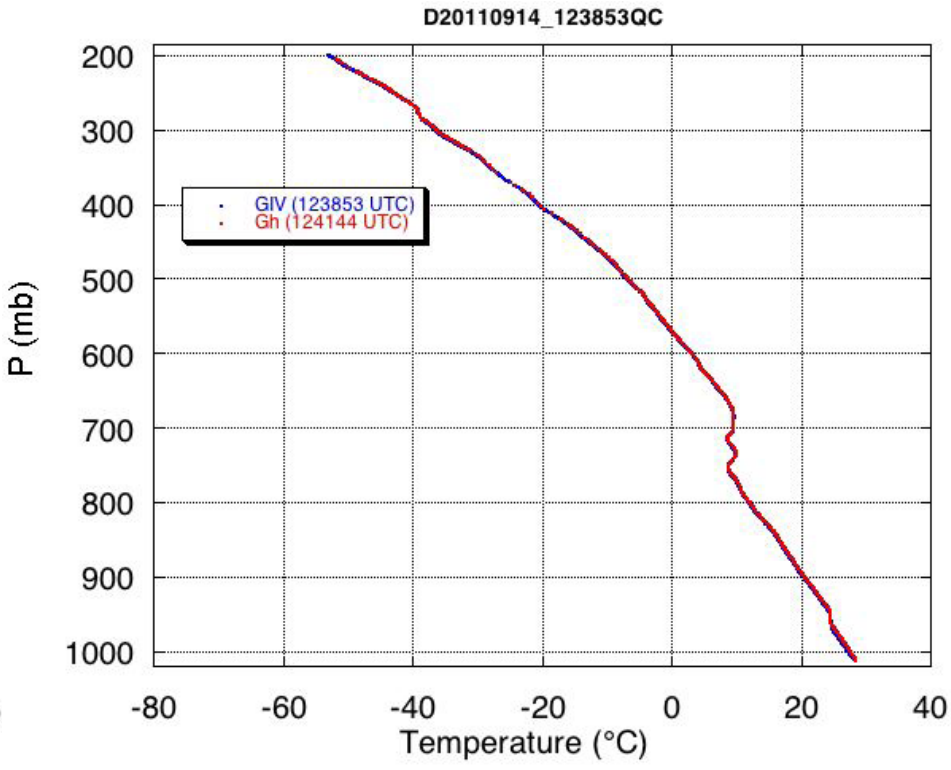


Typical distance between GH and GIV drops is 5-10 km

Dropsonde pairs with some of the larger and smaller differences: Temperature

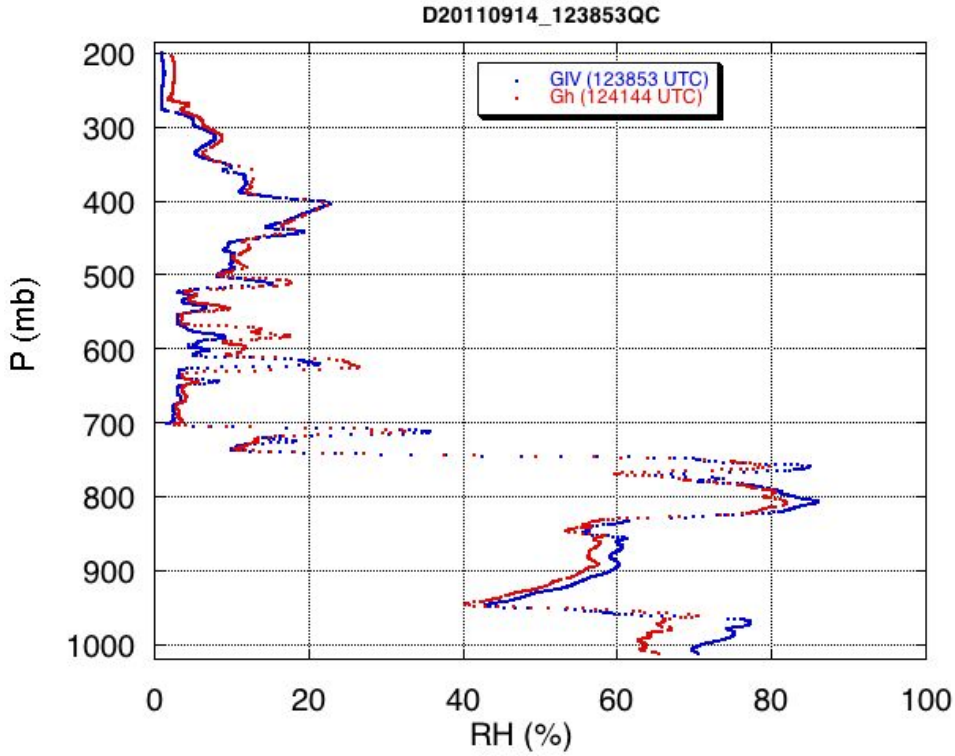


Largest ~1.5°C

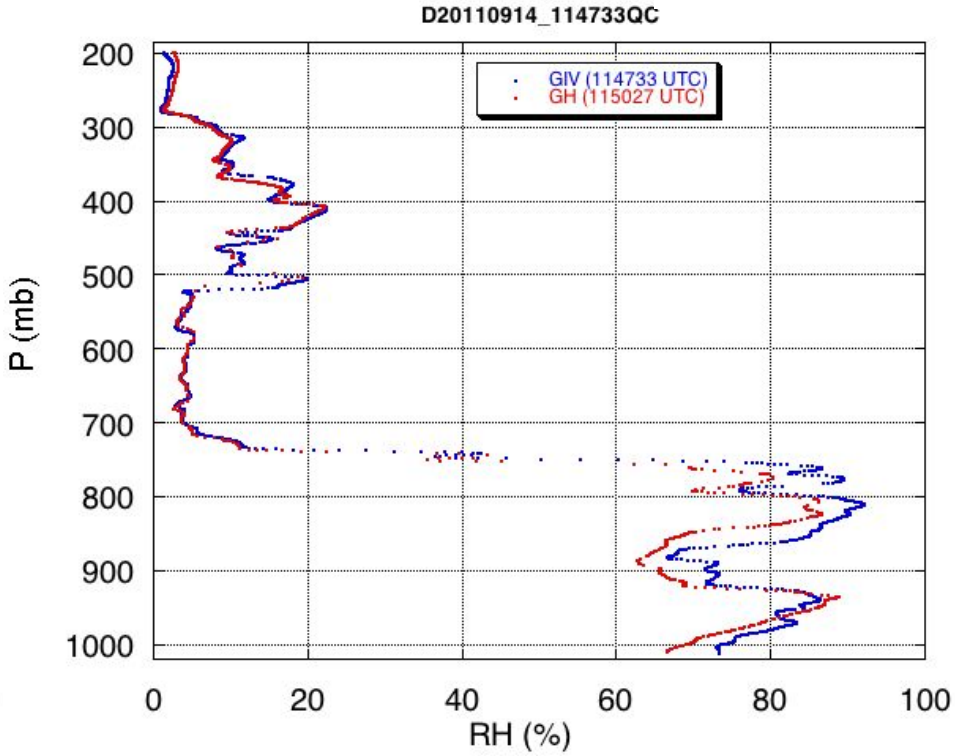


Smallest <0.5°C

Dropsonde pairs with some of the larger and smaller differences: Relative humidity

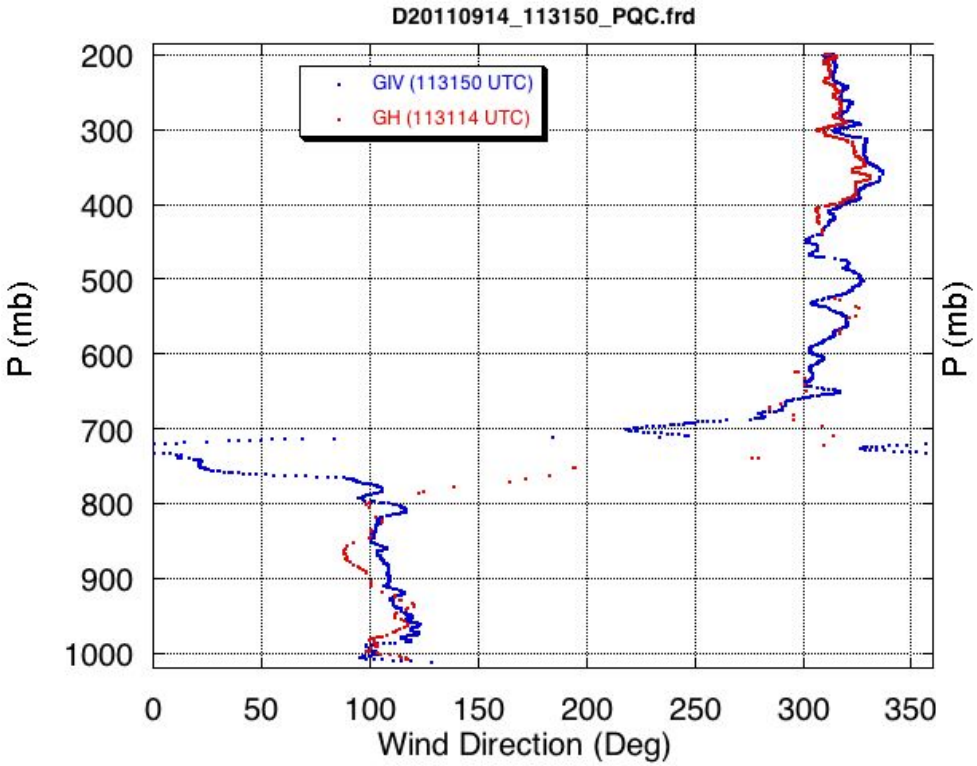


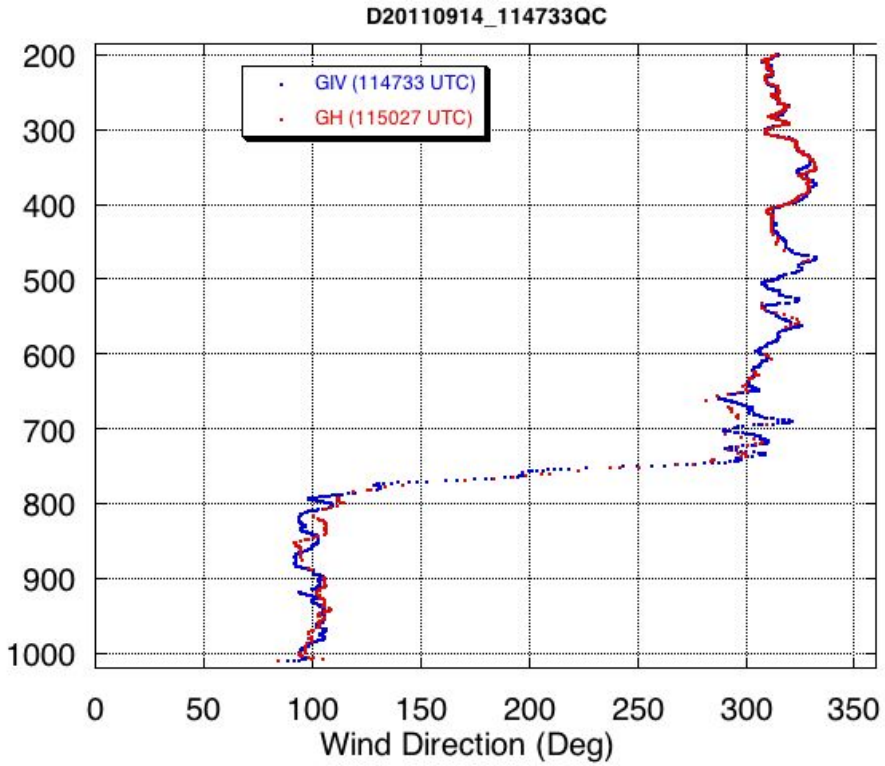
Largest 10-15%



Smallest ~5%

Dropsonde pairs with some of the larger and smaller differences: Wind direction

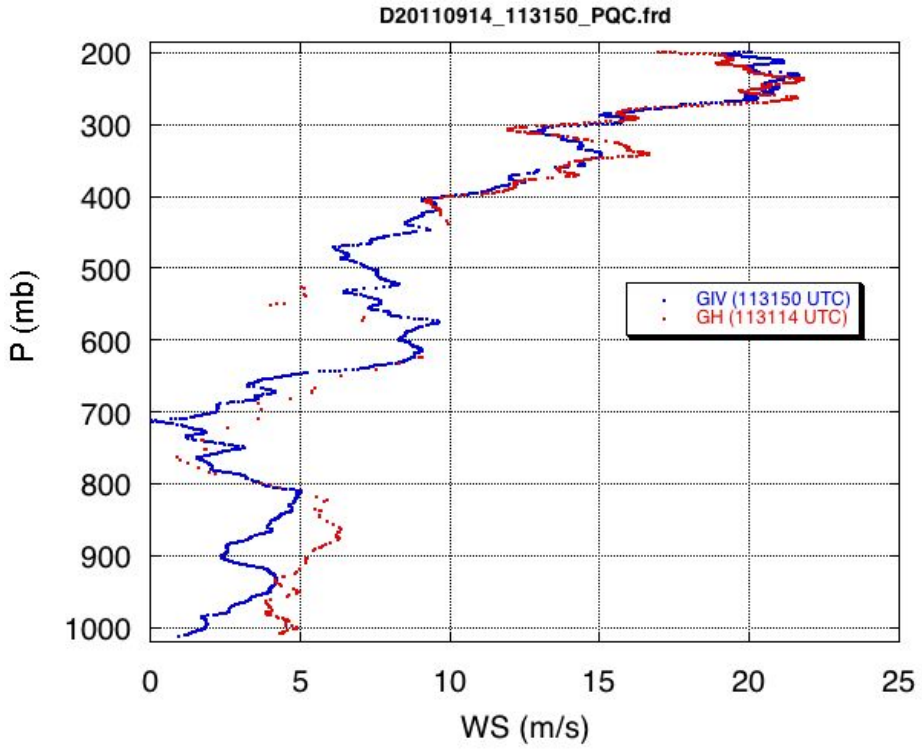


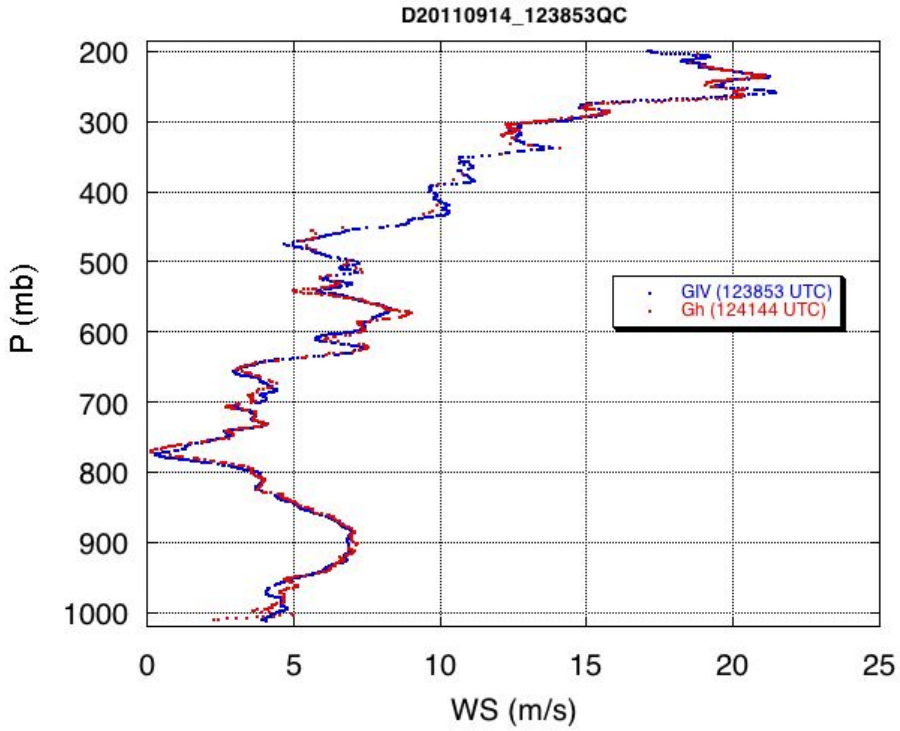


Largest >30° over abrupt wind shift near 750 mb, <30° elsewhere

Smallest <20°

Dropsonde pairs with some of the larger and smaller differences: Wind speed





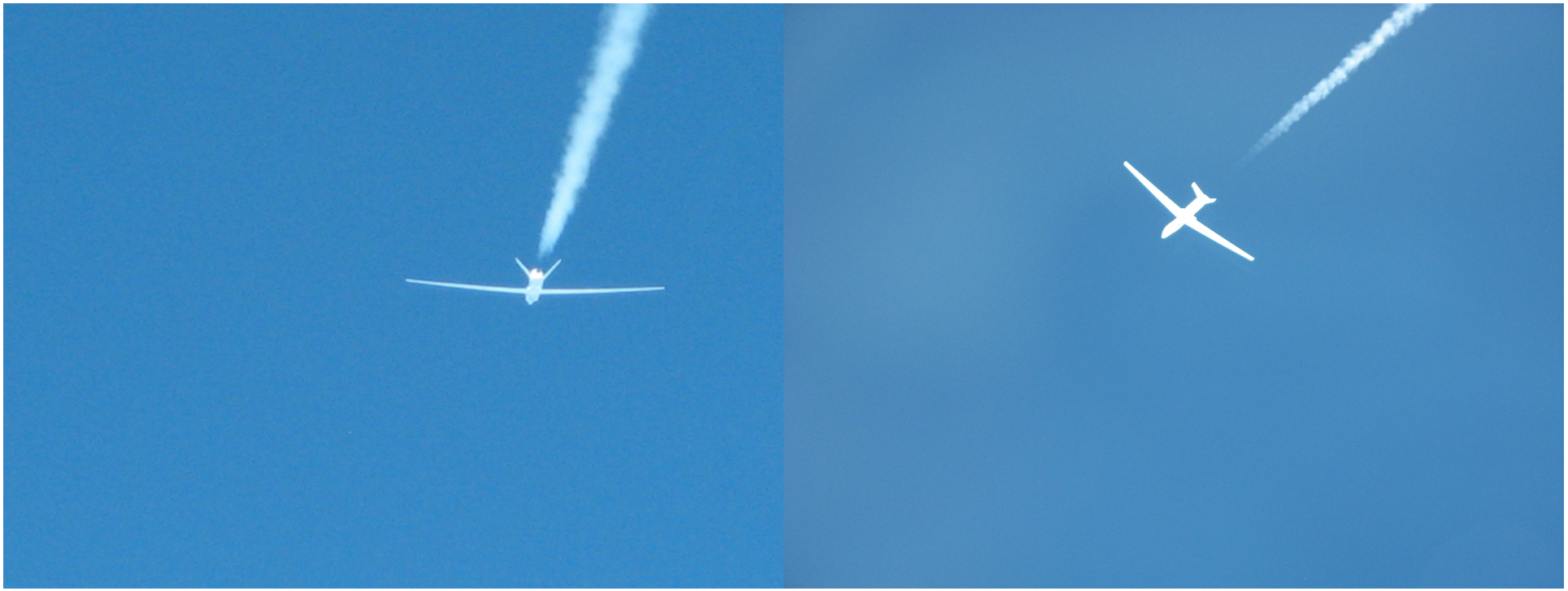
Largest ~4 m/s

Smallest <2 m/s

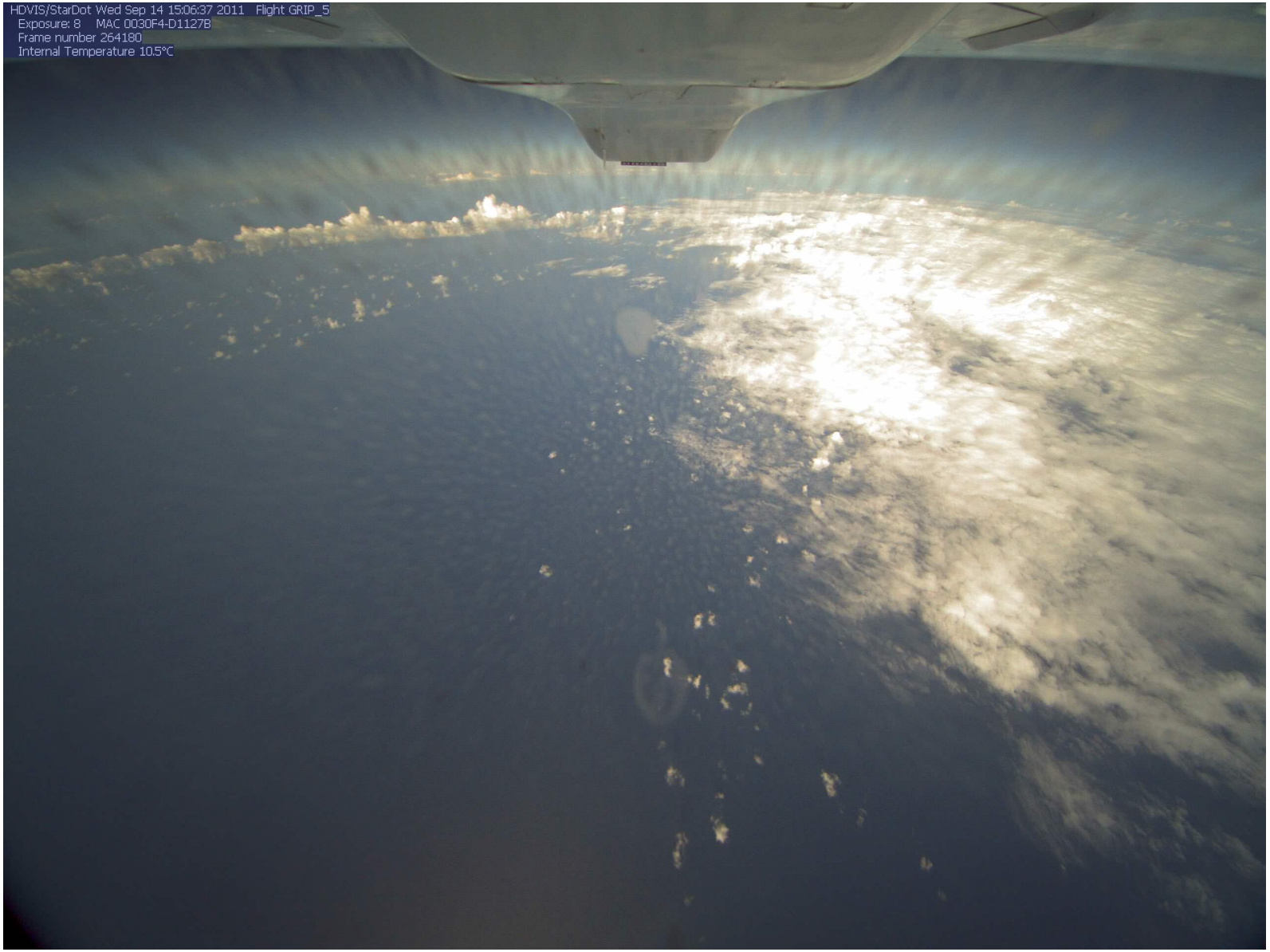
Key Accomplishments—Gulf Flight

- All instruments performed well, collected data through the G-IV intercomparison.
- S-HIS will require air inlet mods for cooling.
- Dropsonde system had jam at end of comparison
  - Was able to reproduce the problem on the ground
  - Fix identified and will be implemented for next year
- Flight to Atlantic cut short since no operational dropsonde system
- Coordination between pilots and Houston ATC worked very well
- Flight was 19 hours,32 minutes (Take off Sept 13 at 7:55pm local and landing Sept 14 at 3:27pm local)

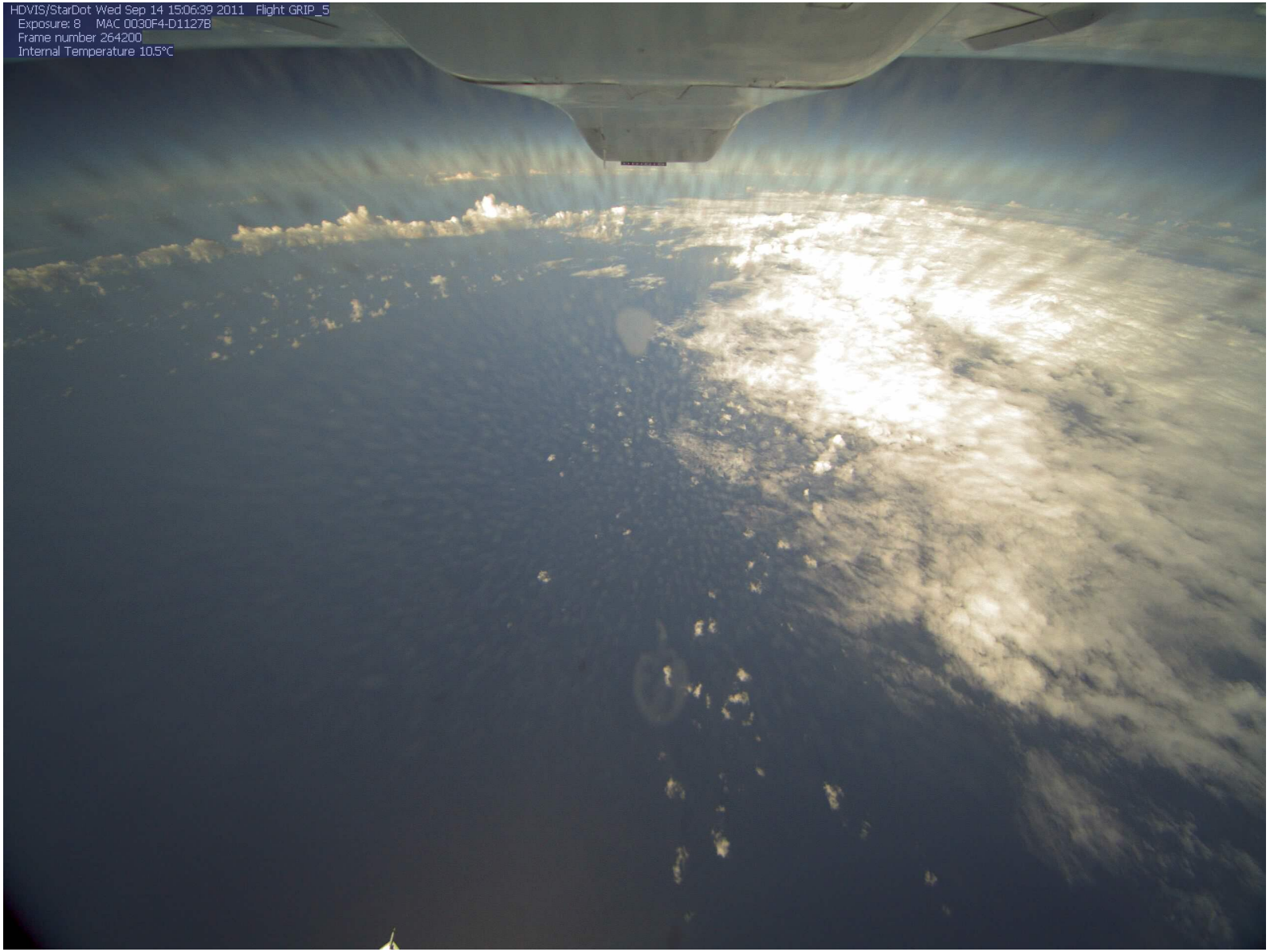
Views of the GH from the G-IV



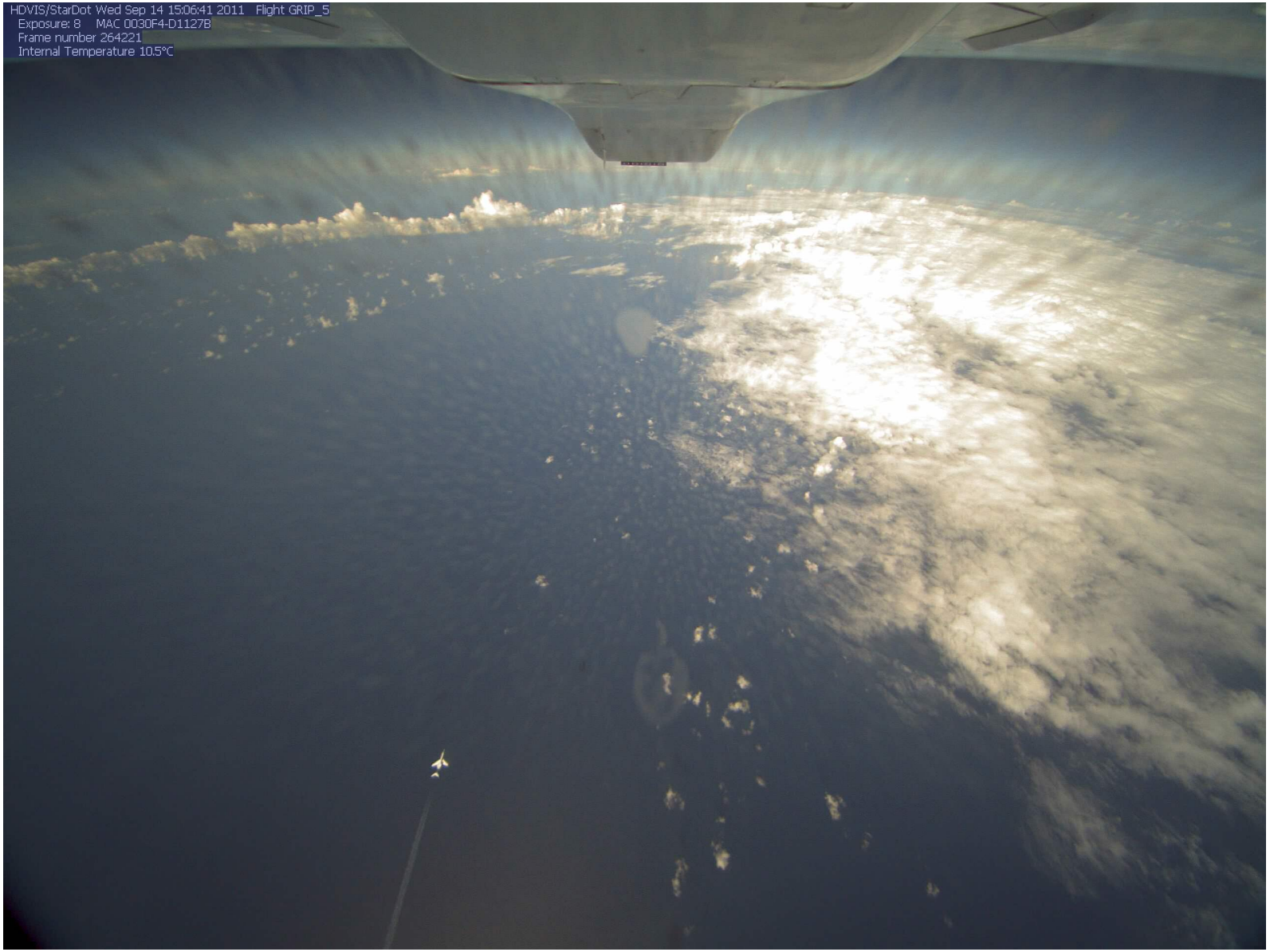
HDVis Image of NOAA G-IV Underpass



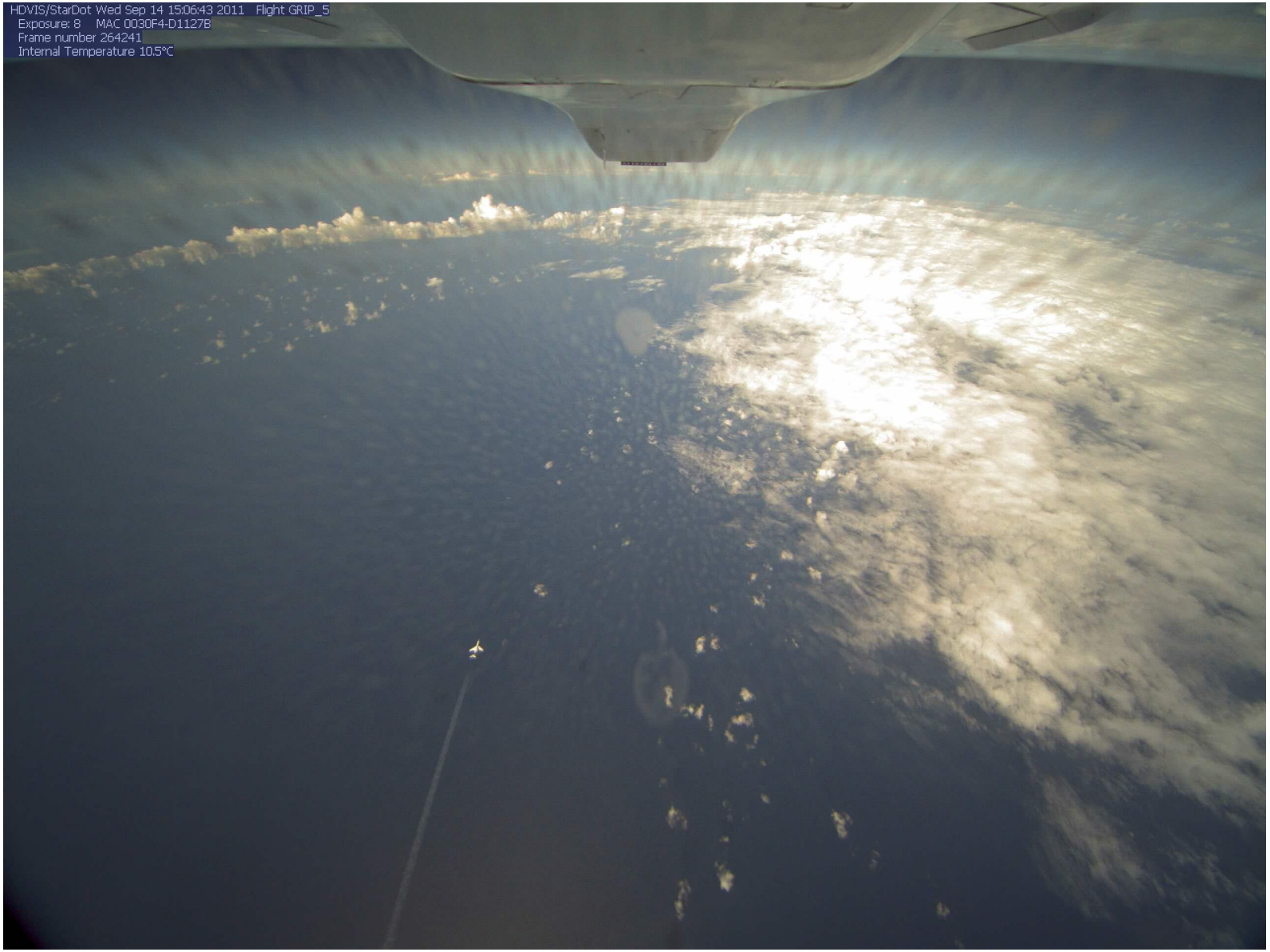
HDVis Image of NOAA G-IV Underpass



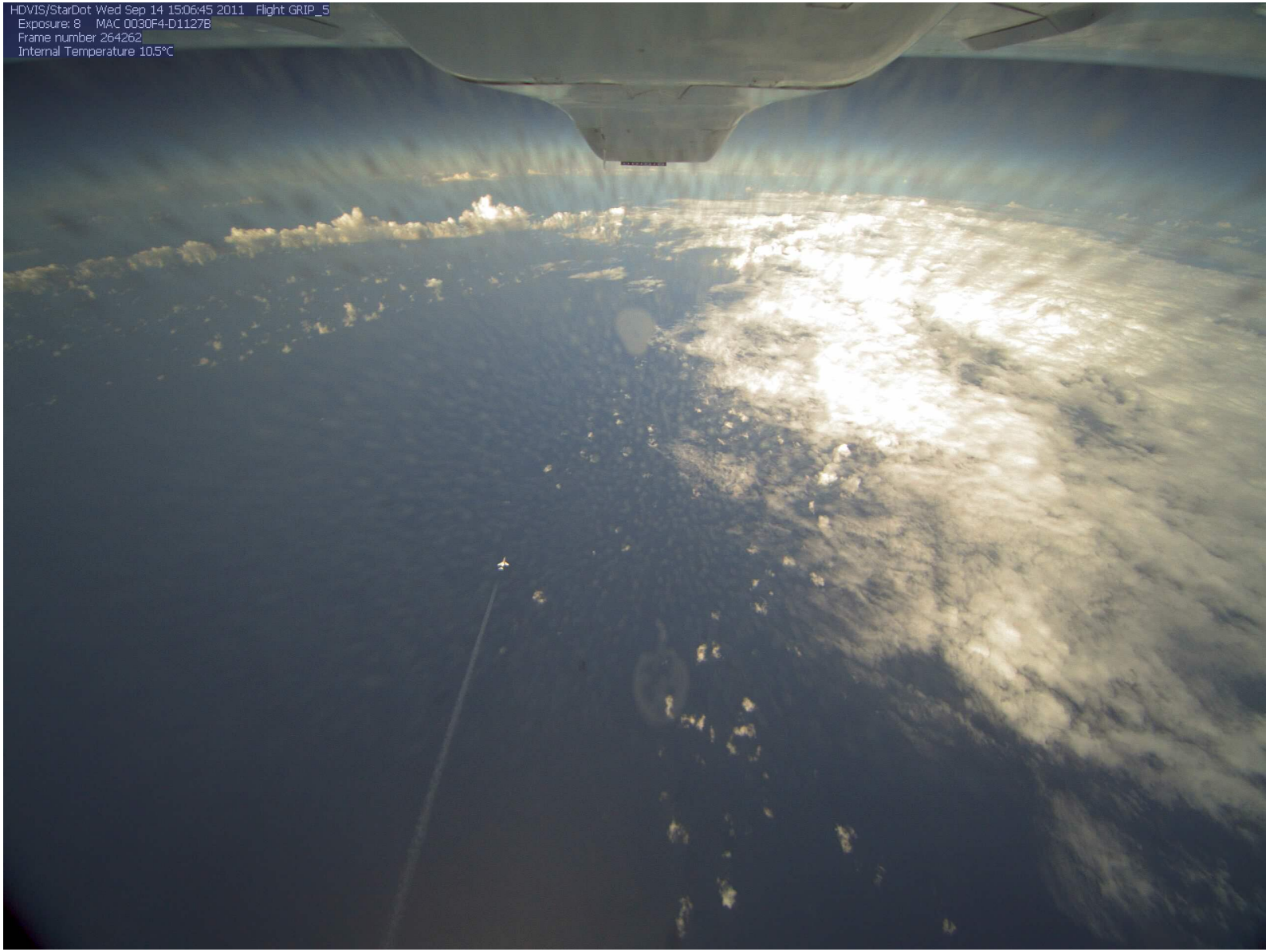
HDVis Image of NOAA G-IV Underpass



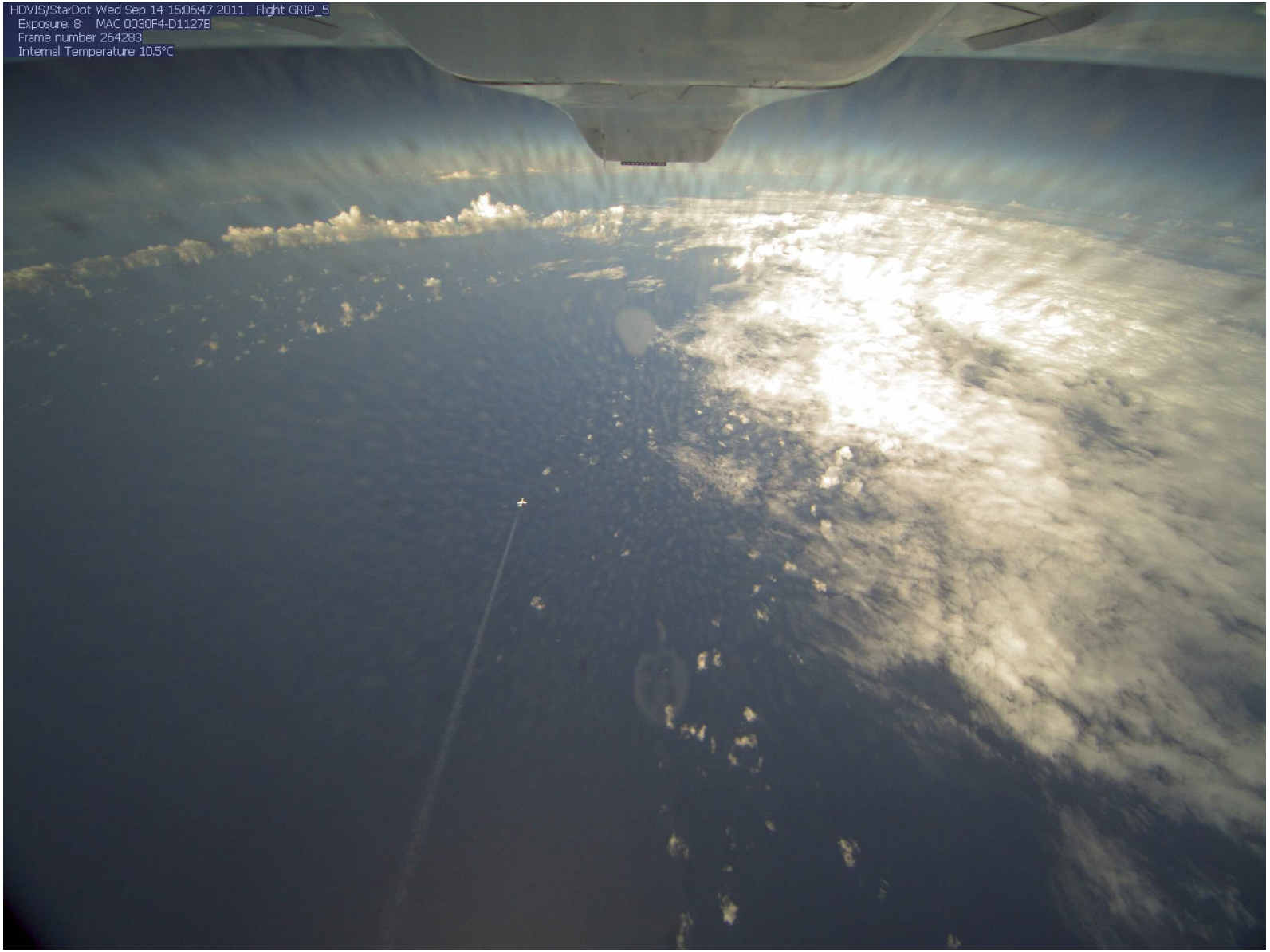
HDVis Image of NOAA G-IV Underpass



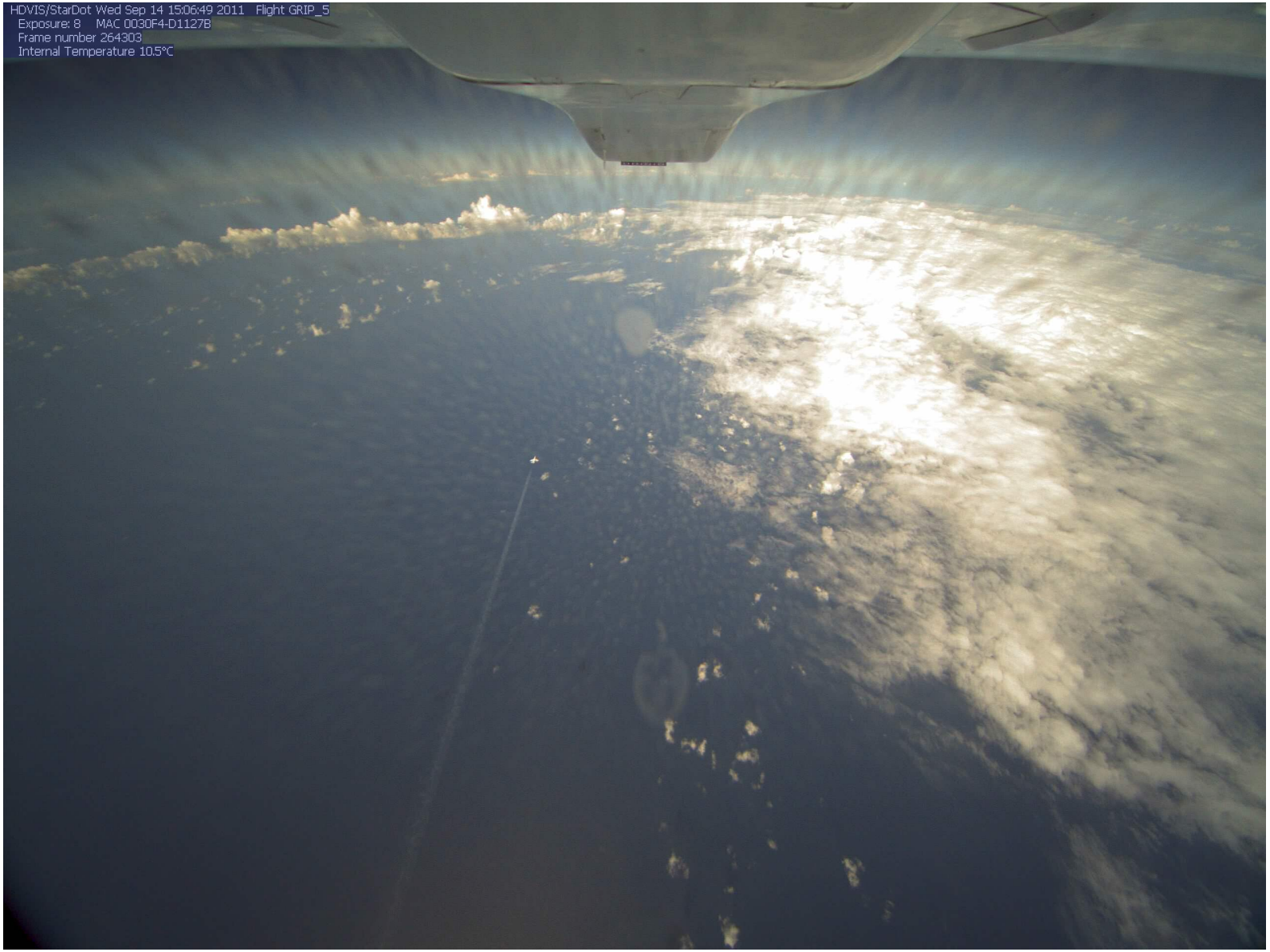
HDVis Image of NOAA G-IV Underpass



HDVis Image of NOAA G-IV Underpass



HDVis Image of NOAA G-IV Underpass



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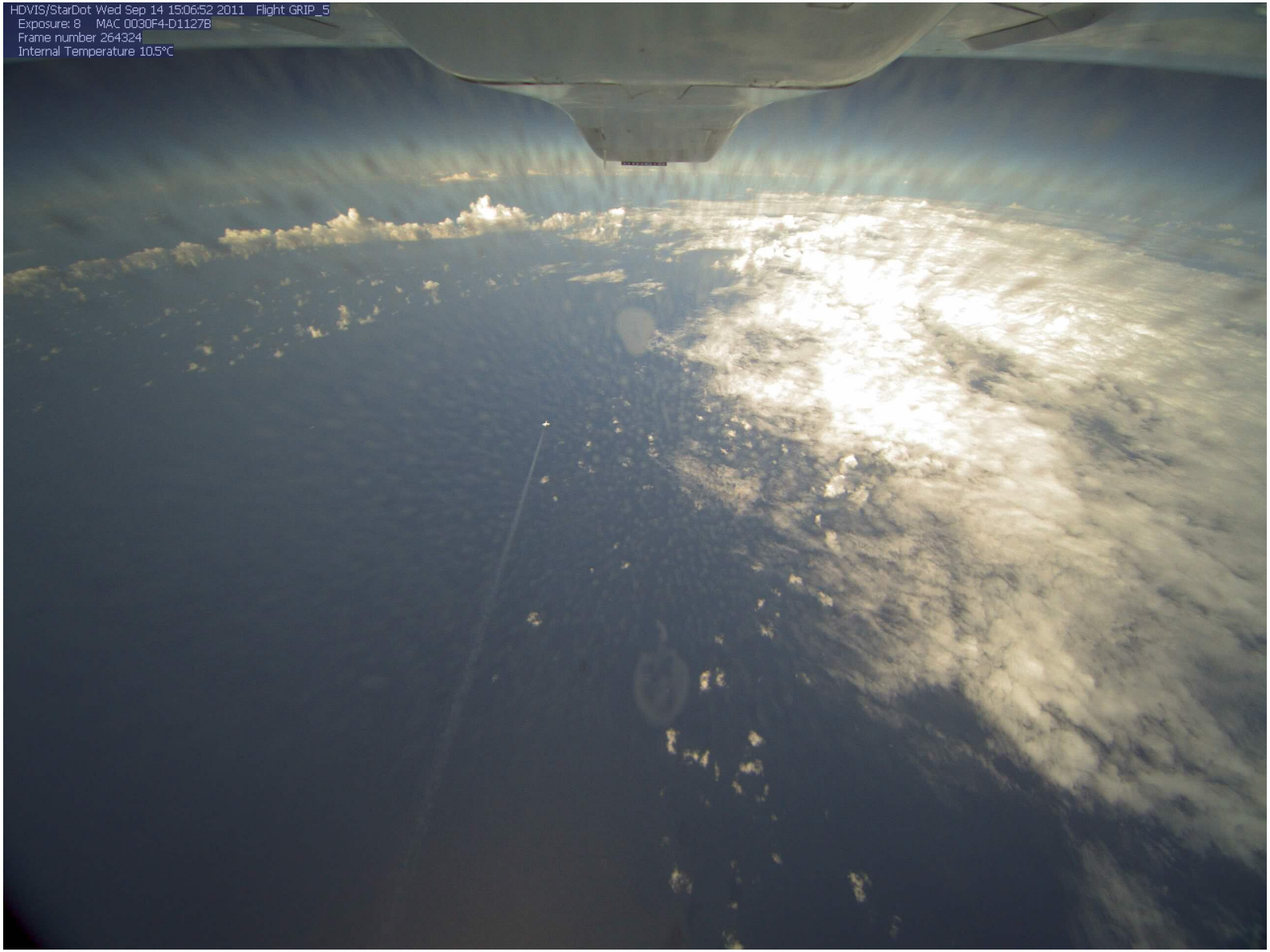
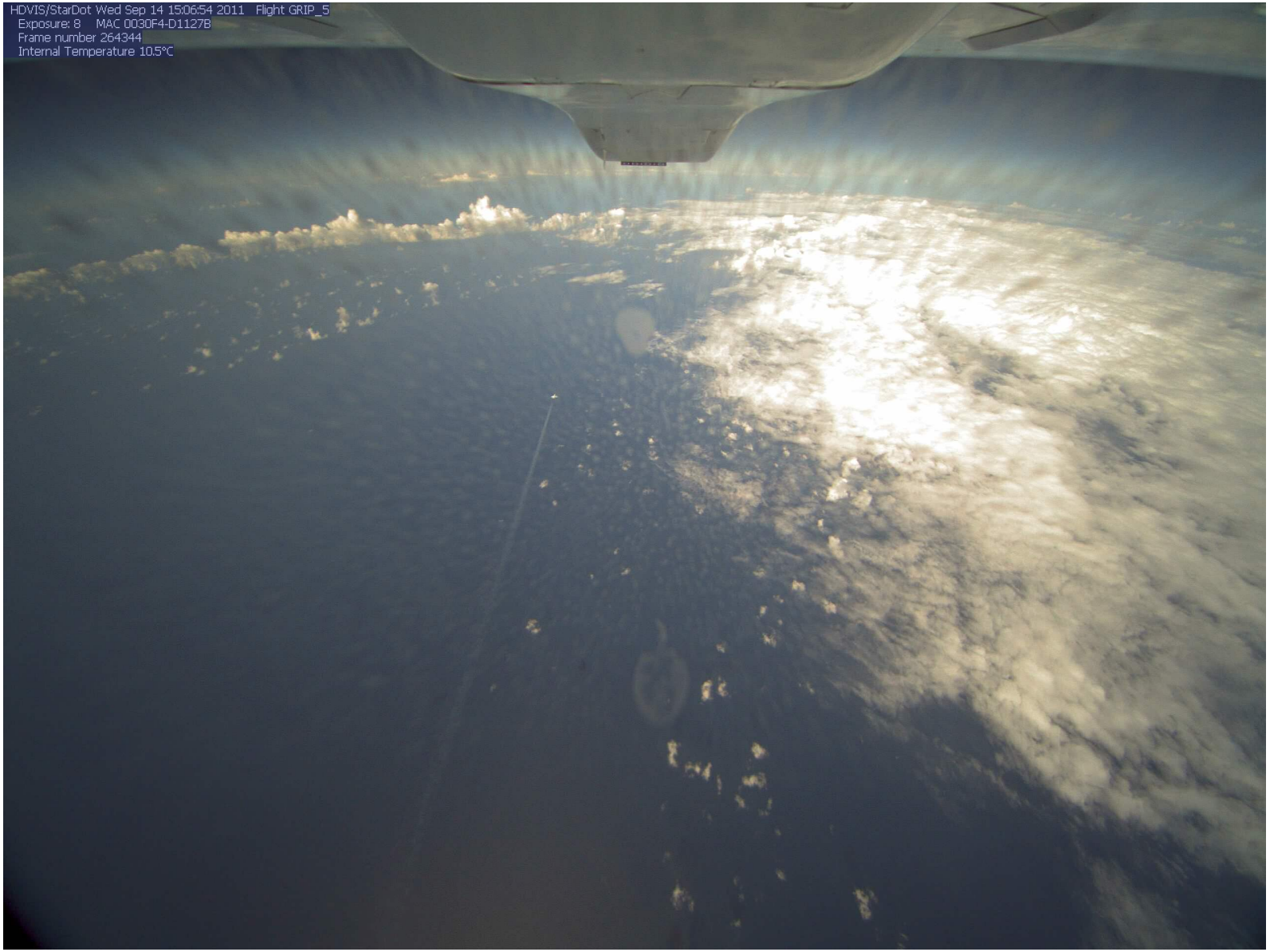
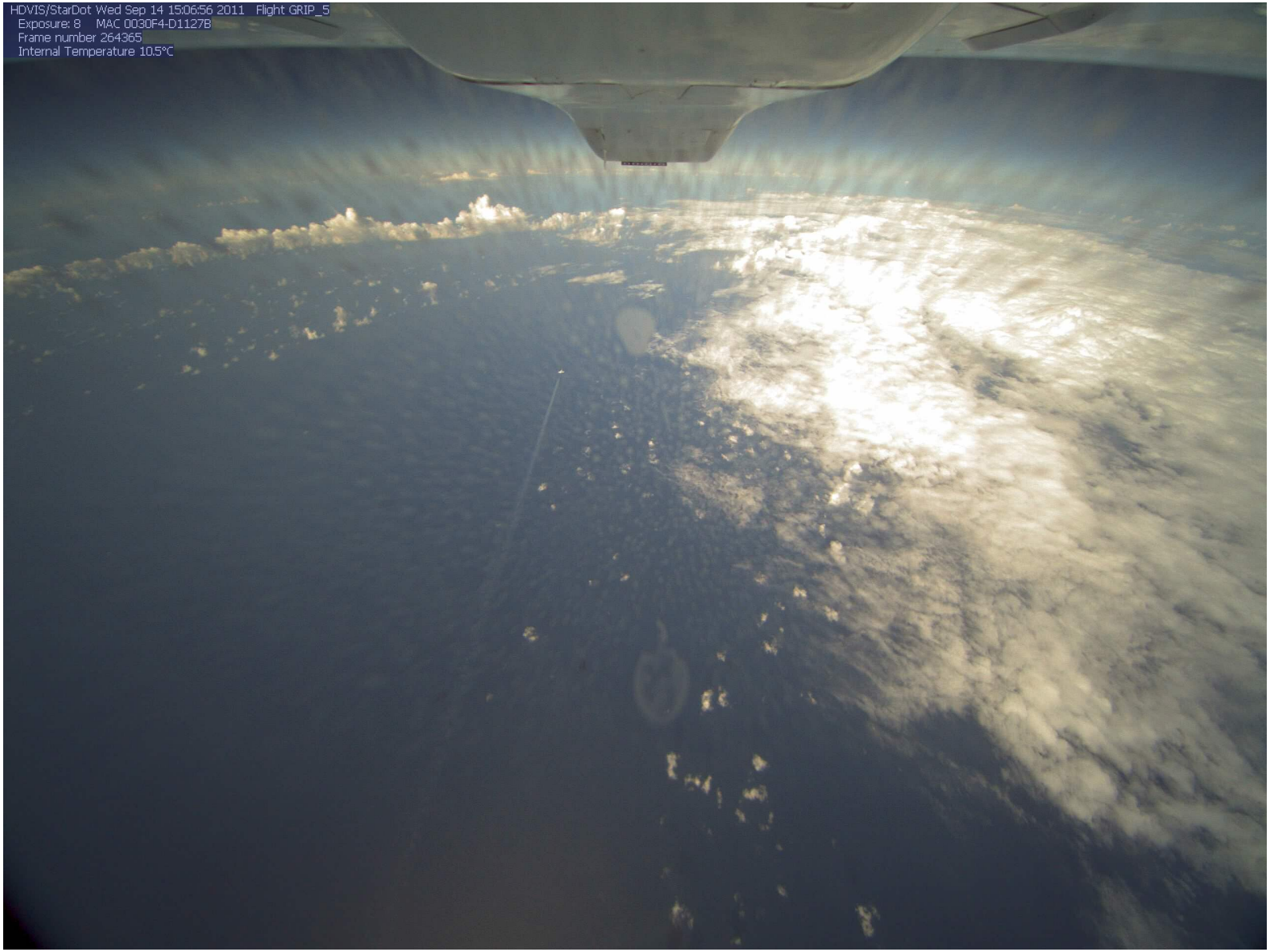


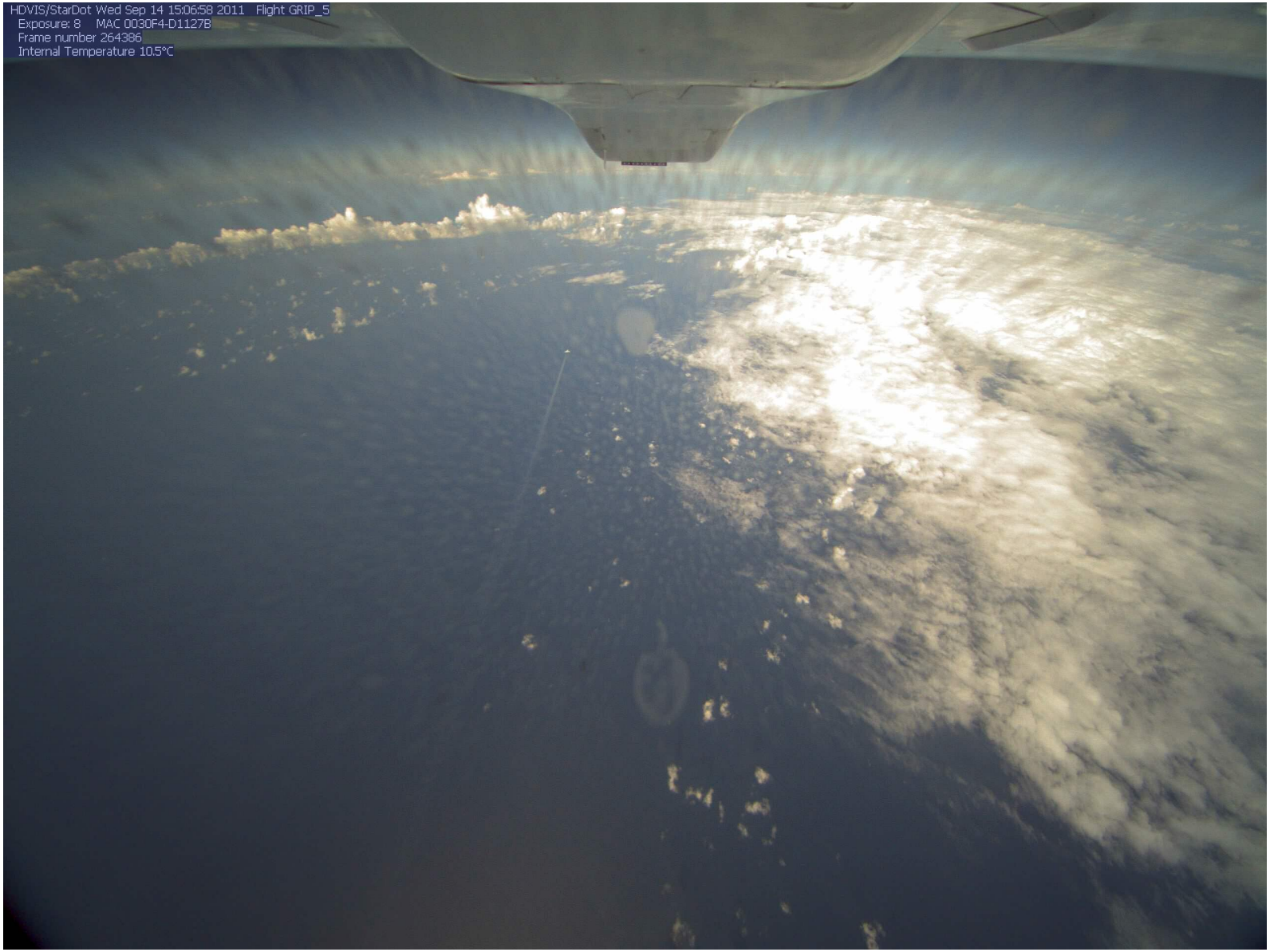
HDVis Image of NOAA G-IV Underpass



HDVis Image of NOAA G-IV Underpass



HDVis Image of NOAA G-IV Underpass



HDVis Image of NOAA G-IV Underpass